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GEOLOGICAL SURVEY OF OHIO

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GEOLOGICAL SURVEY OF OHIO

J. A. BOWNOCKER, State Geologist

FOURTH SERIES, BULLETIN 12

THE BREMEN OIL FIELD

By J. A. BOWNOCKER

Published by authority of the Legislature of Ohio under the
supervision of the State Geologist.

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COLUMBUS, OHIO, OCTOBER, 1910

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To Governor Judson Harmon:

Dear Sir:—I submit herewith Bulletin 12 of the Geological Survey, entitled The Bremen Oil Field. It includes, however, a review of the search for the Clinton sand from Lake Erie south to the Ohio River. Little drilling is now being done in the Trenton limestone fields of northwestern Ohio and work is comparatively slack in the southeastern quarter of the State, after more than ten years of extensive drilling. Probably the Clinton sand will next be thoroughly tested and it is hoped that this Bulletin will aid in the work.

Respectfully submitted,
J. A. Bownocker,
State Geologist.

Columbus, October 15, 1910.

THE SURVEY IN ITS RELATIONS TO THE PUBLIC.

The usefulness of the Survey is not limited to the preparation of formal reports in important topics. There is a constant and insistent desire on the part of the people to use it as a technical bureau for free advice in all matters affecting the geology or mineral industries of the State. A very considerable correspondence comes in, increasing rather than decreasing in amount, and asking specific and particular questions on points in local geology.

The volume of this correspondence has made it necessary to adopt a uniform method of dealing with these requests. Not all of them can be granted, but some can and should be answered. There is a certain element of justice in the popular demand for such information, from the fact that the geological reports issued in former years were not so distributed as to make them accessible to the average man or community today. The cases commonly covered by correspondence may be classified as follows:

1st. Request for information covered by previous publications.—This is furnished where the time required for copying the answer is not too large. Where the portion desired cannot be copied, the enquirer is told in what volume and page it occurs and advised how to proceed to get access to a copy of the report.

2nd. Requests for identification of minerals and fossils.—This is done, where possible. As a rule, the minerals and fossils are simple and familiar forms, which can be answered at once. In occasional cases, a critical knowledge is required and time for investigation is necessary. Each assistant is expected to co-operate with the State Geologist in answering inquiries concerning his field.

3rd. Requests from private individuals for analyses of minerals and ores, and tests to establish their commercial value.—Such requests are frequent. They cannot be granted, however, except in rare instances. Such work should be sent to a commercial chemical laboratory. The position has been taken that the Geological Survey is in no sense a chemical laboratory and testing station, to which the people may turn for free analytical work. Whatever work of this sort is done, is done on the initiative of the Survey and not at the solicitation of an interested party.

The greatest misapprehension in the public mind regarding the Survey is on this point. Requests for State aid in determining the value of private mineral resources, ranging from an assay worth a dollar, up to drilling a test well costing several thousand dollars, represent extreme cases. At present there is no warrant for the Survey making private tests, even where the applicant is entirely willing to pay for the service. In many cases individuals would prefer the report of a State chemist or State geologist to that of any private expert, at equal cost, because of the prestige which such a report would carry. But it is a matter of doubt whether it will ever be the function of the Survey to enter into commercial work of this character; it certainly will not be unless explicit legal provisions for it are made.

4th. Requests from a number of persons representing a diversity of interests, who jointly ask the Survey to examine into and publicly report upon some matter of local public concern.—Such cases are not common. It is not always easy to determine whether such propositions are really actuated by public interest or not. Each case must be judged on its merits. The Survey will often be prevented from taking up such investigations by the lack of available funds, while otherwise the work would be attempted.

The reputed discovery of gold is one of the most prolific sources of such calls for State examination. It usually seems wise and proper to spend a small sum in preventing an unfounded rumor from gaining acceptance in the public mind, before it leads to large losses, and unnecessary excitement. The duty of dispelling illusions of this sort cannot be considered an agreeable part of the work of the Survey, but it is nevertheless of very direct benefit to the people of the State.

PUBLICATIONS OF FOURTH GEOLOGICAL SURVEY OF OHIO.

Title of Volume.	Date of Issue.	Number of Pages.	Number of Copies Printed.	State Geologist.
Bulletin 1—Oil and Gas	1903	320	8,000	Edward Orton, Jr.
Bulletin 2—Uses of Cement	1904	260	6,000	Edward Orton, Jr.
Bulletin 3 Manufacture of Cements	1904	391	4,000	Edward Orton, Jr.
Bulletin 4 Limestones and Lime	1906	365	4,000	Edward Orton, Jr.
Bulletin 5—Sand-Lime Brick	1906	79	4,000	Edward Orton, Jr.
Bulletin 6—Bibliography ...	1906	332	3,500	Edward Orton, Jr.
Bulletin 7 Nomenclature of Geological Formations...	1905	36	3,500	Edward Orton, Jr.
Bulletin 8 Salt Deposits and Salt Industry	1906	42	3,500	Edward Orton, Jr.
Bulletin 9—Coal	1908	342	6,000	J. A. Bownocker.
Geological Map of Ohio......	1909	....	4,875	J. A. Bownocker.
Bulletin 10—Middle Devonian	1909	204	3,500	J. A. Bownocker.
Bulletin 11—Roofing Tiles ..	1910	476	3,500	J. A. Bownocker.
Bulletin 12—Bremen Oil Field	1910	68	3,500	J. A. Bownocker.
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CHAPTER I.

THE BREMEN OIL FIELD.

The discovery of the Bremen oil field is a result of the close association of oil and gas. As is well known, every oil well is to a greater or less extent a gas well, and large gas fields are seldom remote from oil. Gas was discovered in the Clinton at Lancaster February 1, 1887, and at Newark in May of the same year.[1] In the spring of 1888 the fuel was found at Thurston. These discoveries, while not large, were at widely separated localities and insured extensive drilling. The result was the discovery and development of one of the finest gas fields ever known.

Oil, however, is usually more profitable than gas, and almost from the time of the discovery of the latter in the Clinton the search for oil has gone on. For years the result was discouraging, but the driller for oil is as persevering as the miner who seeks the precious metals. The first pool of commercial proportions secured in the Clinton formation was in Jackson Township along the northern border of Vinton County. In August, 1899, a well was completed, which, while not large, was profitable, and of course other holes were started at once, the result being the location and development of a small pool of oil. The second discovery of the fuel in a commercial way was in the southeastern corner of Knox County in August, 1904. In December of the following year a paying well was completed near Butler in the southeastern part of Richland County, and started flowing at an estimated rate of 200 barrels the first day. The oil was "water white," and the field is one of the most remarkable yet found in Ohio, though it was not a large producer.

In the early spring of 1907 a well was completed on the Weingartner farm between Pleasantville and Rushville in Fairfield County, and began flowing oil at approximately 75 barrels per day. In July of the same year a well was completed on land of Frank Kittle in the adjacent township of Brush Creek and proved to be a success. These two wells mark the opening of the Bremen field and the real beginning of the Clinton as a source of oil.

Location.—At present it includes parts of Rush Creek and Richland Townships of Fairfield County; Jackson, Reading and Pike Townships, and to a smaller extent several others of Perry County. As the map shows, it is not one large field, but rather a number of small more or less disconnected areas. Thus we have the Pleasantville, Rushville, Bremen, Junction City and Straitsville pools. Whether or not further drilling will unite these is an open question. At present the indications are that the field is somewhat spotted, but that the Bremen and Junction City pools, at least, will unite, forming a continuous area from Bremen to New Lexington.

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[1] Orton, Edward. *Geol. Surv. of Ohio*, Vol. VI, pp. 370-372; also Bownocker, J. A., Bull. I, Fourth Ser., pp. 102, 106, 107.

Early Drilling.—The discovery of this pool is due in no small measure to the confidence and perseverance of one man, Mr. J. E. Purvis. Its subsequent development is likewise due quite largely to the same individual. Nearly twenty years ago he secured options on about 5,000 acres of land around Bremen and attempted to organize a company to drill for oil. He believed that fuel was present because of the great reservoirs of natural gas a few miles to the west. Failing to enlist the necessary capital, the options were lost, and two more attempts had to be made before drilling began. About 1895 the Rush Creek Oil & Gas Company was organized, the capital stock at first being $10,000, but was increased later to $50,000. Stock to the value of $18,000 was sold.

The first well was drilled early in 1896 on the Stewart farm a short distance north of Bremen. When a depth of 1,790 feet had been reached, a heavy flow of gas, estimated at 5,000,000 cubic feet per day, was encountered, and drilling ceased. Lines were laid to Bremen, Rushville and West Rushville, giving those villages their first supply of natural gas, but about eighteen months later a flood of salt water ruined the well. So favorable an impression did this well make on capitalists that $100,000 was offered for the leases held by the company, which would have left $82,000 to be distributed among stockholders, but the offer was rejected.

The next venture was on the Steamen farm, a mile and a quarter southeast of Bremen. The Clinton sand was found in 1896, at a depth of about 2,510 feet, and contained some oil, but the shales above the sand caved badly, and in about six months the well was abandoned without having shown what it was worth. Mr. Purvis thinks it would have produced 15 barrels per day.

The third effort of the company was on the Rowles farm, about the same distance southwest of Bremen. Fourteen months were consumed in drilling this well, which was less encouraging than either of the preceding ones. At about this stage the company went into a receiver's hands, and the double liability law was enforced that debts might be paid. In this way the Rush Creek Oil & Gas Co. went out of existence.

Late in 1896, Purvis, with two practical oil men, formed a partnership and drilled a well a mile and a quarter northeast of Bremen on the Nixon farm. The Clinton sand showed oil, but not enough, it was thought, to warrant shooting, so the well was abandoned and the partnership terminated.

Within the next ten years Purvis took up leases two or three times, but could not raise the money necessary for drilling. In the spring of 1907 oil was gotten in a well drilled for gas about seven miles northwest of Bremen. The coveted fuel had now been disclosed on three sides of the village, and naturally this strengthened the conviction of Purvis that oil in commercial quantities existed in the vicinity of Bremen and made possible the organization of the Bremen Gas & Oil Co. in 1907.

DISCOVERY AND DEVELOPMENT.

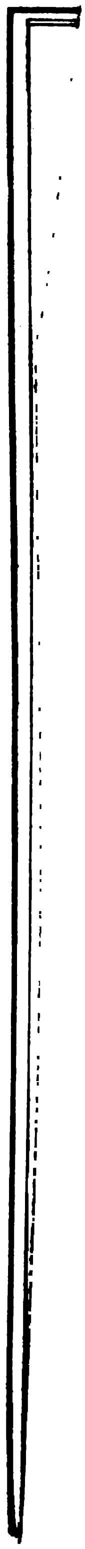
Bremen Pool.—On May 17, 1907, the company just named, and which was to play so important a part, was organized. The capital stock was fixed at $50,000, in shares of $25.00; about four hundred and twenty-eight shares were sold and eighty additional ones were given in exchange for about 10,000 acres of land that had been leased by Purvis & Ruff, in Rush Creek Township, Fairfield County, and Jackson Township, Perry County, The board of directors chosen consisted of J. E. Purvis, A. F. Turner, L. Olive, L. H. Kennedy, Lewis E. Ruff, Charles Bloom and W. S. Turner, all of Bremen, Ohio. The board organized by electing A. F. Turner, President, and L. E. Huddle, Secretary.

The first place selected for testing was the farm of F. M. Kittle, on the northeast quarter of Section 11 of Rush Creek Township. No special reason existed for this location; it was simply one of the leases held by the company and was neither more nor less promising than other tracts. Drilling began June 12, 1907, and the tools penetrated the Clinton sand late in July. Some oil was found and the sand was shot with 60 quarts of nitroglycerine that was hauled in a wagon from near Marietta. In drilling, the casing extended simply to the base of the Berea, but when oil was found a string of 2,574 feet was set on the top of the Clinton, thus insuring a dry hole so far as water was concerned. After shooting, the well flowed several times, but the water proved too strong. When the casing had been inserted and the well cleaned, a pump was attached and the production started at 10 barrels per day. It is now (June, 1910), pumping about half that quantity. While this well was not much of a success it was encouraging, and in August a second one was begun. Stockholders urged that leases nearer Bremen be tested, and to satisfy them a location was made on the farm of G. W. Baldwin, just north of the village. The Clinton sand was found, but it was hard and without oil or gas. A shot of 80 quarts of nitroglycerine did not improve matters.

These two wells, one a complete failure and the other a small producer, emptied the treasury of the company, but the stockholders with few exceptions doubled their shares and the drill was started again. The location was near their first well and on the farm of J. W. Huston, southeast quarter of Section 2. The Clinton sand was penetrated about October 1, 1907, and began flowing oil at the approximate rate of 140 barrels per day. Thus after nearly twenty years of effort Purvis began reaping his reward. The well was very profitable and in July, 1910, was pumping about 20 barrels each day. Naturally the company did not go far for its next location which was on the Householder farm, adjoining the Huston on the east. The Clinton sand was reached in February, 1908, and the well began flowing at the rate of 250 barrels per day; in July following, it was producing at the rate of 100 barrels, and two years later 10 barrels daily. Of course this well attracted wide attention and the rush to the new field began. Leases were sought after far and near, and rentals as high as $12.50 an acre per year were paid. The Purvis farm joins the Householder on the east and a well completed on it July 10, 1908, began producing 300 barrels per day; by September 1, 1910, this rate had decreased to 8 barrels.

Other wells were sunk by this company as fast as the drill could be forced down and with marked success, obtaining a daily production of 1,000 barrels in 1909 and maintaining this for the following 12 months or thereabouts. Stock rose rapidly in value and in May, 1909, sold as high as $625 a share. By January 1, 1910, twelve 50 per cent. dividends had been paid. The oil commands the Pennsylvania price and sold for $1.78 per barrel during approximately the first two years of the company's history. It then began dropping and reached $1.30, at which it is now selling. By the close of 1909 the company had drilled 90 wells and 70 of these were producers. The decline in the price of oil naturally interfered with dividends, and by July 1, 1910, the stock had dropped to about $300 a share. By January 1, 1910, the Carter Oil Company had secured a controlling interest in the company, and its future is in the hands of that great corporation. Among its first acts was the sale at par and pro rata among the stockholders of the balance of the $50,000 treasury stock of the Bremen Gas and Oil Company. It holds leases of about 8,000 acres in the Bremen field, and will doubtless develop that as rapidly as the condition of the market warrants. No dividends have been paid since January 1, 1910, and none were expected in the near future (July, 1910).

Thus far, our review has been limited to the fortunes of the Bremen Company. Attention will next be given briefly to a few of the scores of organizations that were formed early in the history of the development. The Avelon Oil & Gas Company was formed in January, 1908, by J. E. Purvis. The capital stock was $75,000, of which $41,000 was sold at $25 a share. Purvis turned over to the company leases on about 2,500 acres, receiving as compensation $2,500 in cash, $10,000 in stock and a promise of one-sixteenth of whatever oil might be secured. Drilling began in the early spring of 1908, on the Elder farm, about a quarter of a mile northeast of the Householder, which proved so great a source of wealth to the Bremen Company. Only a show of oil was secured; the well was shot and then abandoned. The second attempt was on the Holliday farm, about three miles northeast of Bremen, and a 20-barrel producer secured. The third well was located about 200 feet to the west and proved a bonanza. Purvis states that it started at approximately 300 barrels



a day, and averaged 200 barrels for 90 days. September 1, 1910, its production was 20 barrels. The company drilled in all about 15 wells, 11 of which were producers. Two dividends, each of 25 per cent., have been paid, and the stock has sold as high as $300 a share; July 1, 1910, the price was $25.

The Planet Oil & Gas Company was organized late in 1907. It secured two leases about three miles east of Bremen, and drilled sixteen wells, all of which produced. The wells varied in output from 5 to 300 barrels per day, and the profits were large, though the actual figures are not in possession of the Survey.

The David Rodafer Oil & Gas Company, organized April 1, 1909, has been very successful. Its capital stock was $50,000, in shares of $25. The company secured control of the old Rodafer farm of about 145 acres, giving the owners $22,500 in stock for the lease. The land joins Bremen—in fact, part is within the village—and is situated largely in the valley of Rush Creek. Drilling began in June, 1909, and 17 wells, all producers, had been completed by July 1, 1910. In size these ranged from 5 to 375 barrels per day. The maximum production of the lease was 1,100 barrels a day, and on the date just mentioned was 800 barrels. The company has room for six or eight more wells, but reported that these would not be drilled at once. No dividends had been paid, the income having been used for development, but with the cessation of drilling, handsome returns should be received by the stockholders.

The Great Expectation Oil & Gas Company was organized in the autumn of 1909. At first it had only one acre of ground optioned, and this was located about a half mile south of Bremen. A well drilled on this the same season began producing about 30 barrels of oil per day. The company then secured a half-acre lot in the village of Bremen, but outside of the corporation line, and on this a well was drilled. The initial production, according to Purvis, was at a rate of 500 barrels per day, making it the largest producer from the Clinton sand yet secured. Strange to state, the company has not secured additional leases or drilled more wells, but is content with the results secured. By July 1, 1910, it had paid dividends of 650 per cent.

From the first producing territory, about three miles northeast of Bremen, the drill moved in all directions, but with little success to the north and west. Southward the results were more favorable, and by 1908 wells were being secured in the valley of Rush Creek. In the spring of 1909 the drill was at work near Bremen, and late in the year on town lots. Much money has been wasted in this enterprise—not only have wells been drilled on adjacent lots, but in at least one case two have been put down on the same lot. Sometimes the derricks were so close together that there was scarcely room for the tools. Such crowding is a shameful waste of time and money, for what would be profitable with the usual spacing of wells must be unprofitable when a half dozen are drilled where one should be. By July 1, 1910, thirty wells, six of which were failures, had been drilled in Bremen, and three strings of tools were at work. The productive territory appears to lie in the main along the eastern side of the town, but further drilling may extend it westward.

During the first year the oil was pumped into tanks along the railroad, and then run by gravity into tank cars. In 1908 the Buckeye Pipe Line Company erected a pumping station in the valley at Bremen, and laid a three-inch line. A little later this was replaced with a four-inch line, and this in turn with a six-inch.

Having reviewed the history of the development around Bremen, attention will be given to other pools in the same part of the State.

Pleasantville Pool.—In March. 1907, a well was completed on the Weingartner farm, Section 18 of Richland Township, Fairfield County, about midway between the villages Pleasantville and West Rushville. It will be noted that this was prior to the first well in the Bremen field proper, which dates from July following. The well began flowing at the rate of about 75 barrels per day. Other wells were drilled as fast as the tools could be forced down, but by the close of 1908 the limits of the field had been determined, and little drilling has been done since that time. The best well reported is on the Stevenson farm, and started flowing at about 200 barrels per day.[1] The producing territory includes parts of Sections 18 and 19, on which about a score of oil wells has been obtained. To the south a few gas wells have been secured, and immediately to the west lies an arm of the great Central Ohio gas field. Eastward from the oil wells seven dry holes have been sunk, and no direct extension in that direction needs be expected.

Rushville Pool.—The Rushville Oil & Gas Company drilled a well on the Wikoff farm, on the southeast quarter of Section 33, about one mile south of the village, in the summer of 1909, and secured a gas well that started producing 1,887,000 cubic feet per day. Two further attempts on the same farm brought similar results. The gas is disposed of to the Logan Gas & Fuel Company at five cents per thousand cubic feet. The next effort was on the Morehead farm, which joins the Wikoff on the north, the result being an oil well which started flowing at the rate of about 75 barrels the first day. Another test on this farm showed oil, but before the well had been cleaned and put to pumping the company sold its holdings. The production is reported to have started at 30 barrels a day. A third well was completed on the same farm in the summer of 1910 with favorable results, and two sets of tools were busy in the field. No dry holes were reported to the east, and an important extension may be made in that direction. Several gas wells are found farther west, though the production from these is not large, and two additional ones were secured near West Rushville, one in the valley near the T. & O. C. R. R. station and the other near the southeastern edge of the village. Four dry holes near these two wells dampen the enthusiasm of the prospector.

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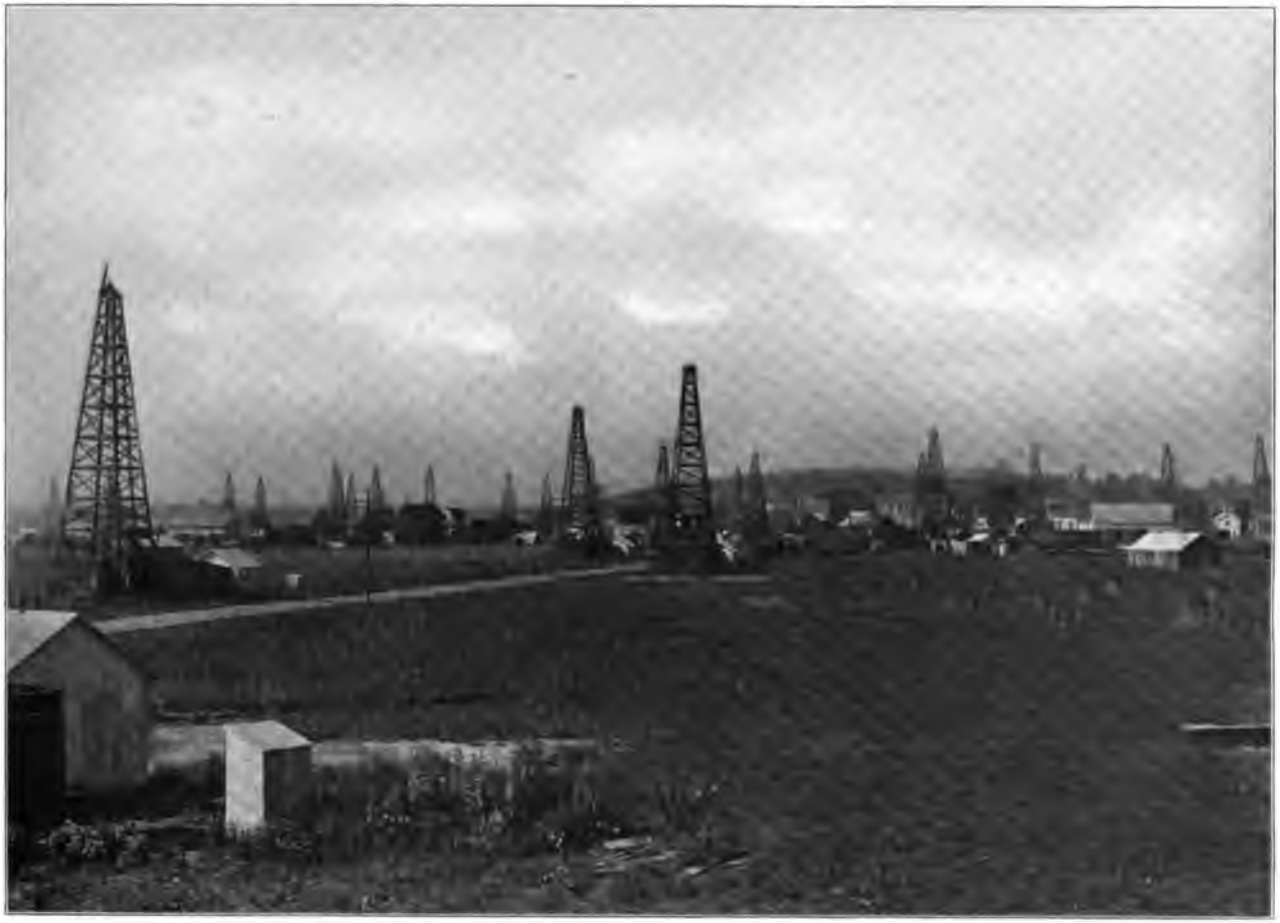
[1] An analysis of the oil from this field may be found on page 17.

PLATE II.



Partial View of the Bremen Pool, with the Village in the Background.

Junction City Pool.—Naturally the success achieved by drilling a few miles to the west aroused the enterprising citizens of Junction City, and on March 14, 1909, the Alberta Oil & Gas Company began drilling within the corporation. The Clinton sand was found at a depth of 2,854 feet, and after shooting with 40 quarts it began flowing oil at the approximate rate of 150 barrels a day. By the middle of July, 1910, it still flowed occasionally, but the production had dropped to 15 barrels per day. The well was sufficient to start the boom, and others were sunk as rapidly as possible. By the date just given, 65 wells, only one of which was dry, had been completed within the corporation of 640 acres, and three strings of tools were at work. Since March, 1910, work has been quieter and the excitement has subsided. Probably the decrease in the price of oil and the fear of further reductions have been the most potent agency in checking the drill. Wells have varied greatly in size, from those scarcely large enough to warrant tubing to Crown No. 2, which was shot about December 1, 1909, and started flowing at the rate of 300 barrels a day. By the middle of the following July its daily output had dropped to 30 barrels. The Perry-Noble No. 3 was another large producer. It was shot April 16, 1910, and started flowing at the rate of 225 barrels a day. Three months later this had dropped to 45 barrels. Of the 65 wells in the corporation, not more than a half-dozen started at 10 barrels or less. Wells of this size are pumped from the start; others flow at first.

Of the many companies formed in the Junction City field only five have paid dividends to date (July 15, 1910). These are as follows: The Holiday Oil & Gas Company, 20 per cent.; The Electric Oil & Gas Company, 10 per cent.; The Alberta Oil & Gas Company, 10 per cent.; The Capitol Oil & Gas Company, 10 per cent.; and The Shamrock Oil & Gas Company, 10 per cent. The receipts, in large part, have generally been used for further drilling; otherwise dividends would have been larger. Much drilling has been done and is still in progress south and west of Junction City, the results being similar to those given for other parts of the Bremen field. The limits of the territory have not been determined.

Some farms in the vicinity of Junction City have been leased since the drilling of the Kochensparger well in 1902. The price has varied from 50 cents to $3.00 per acre, the common figure being $1.00.

New Straitsville Pool.—This lies in Sections 19 and 30 in the extreme northwestern corner of Coal Township. The first test of the Clinton sand was made on the Jones farm, southeast quarter of Section 19. The well was drilled by the Purvis-Martin Oil & Gas Company and was completed July 4, 1909, the Clinton sand being struck at 3,202 and found 25 feet thick. For ten months the well averaged 22½ barrels of oil per day. It was then cleaned and shot for the second time and continued producing at the rate just mentioned. In August, 1909, the company began its second well, located on the Martin land due south of the center of Section 30. The "Big lime" was reached at 2,115 feet; at 2,725 it yielded a heavy flow of brine and at one time the well contained more than 3,000 feet. The top of the Clinton sand was reached at 3,140 feet and the bottom at 3,168. It was shot with 60 quarts of nitroglycerine, but the only reward was a small flow of gas estimated at 250,000 cubic feet per day, and 2½ barrels of oil. The gas was used for additional drilling, and the well is now pumped for oil.

Well No. 2 on the Jones farm was located about 700 feet south of No. 1, and was completed in November, 1909. The Clinton sand was found at a depth of 3,236 feet and the bottom at 3,261 giving it a thickness of 25 feet. The top 4 feet of the sand were very soft and gave a heavy flow of gas, estimated at 2,000,000 cubic feet per day, but the closed or rock pressure was only 460 pounds. After a short time 1,200 feet of salt water appeared in the well and it was ruined. The source of this heavy flow of brine appears to be a mystery to the company, but it doubtless had its origin in the "Big lime." The well was shot, but made no oil at all, and was abandoned.

The fourth well of the company was Martin No. 2 and was located about 50 feet south of the center of Section 30. The desired sand was reached at 3,104 feet and measured 38 feet in thickness. The sand was not uniform; at the top it was quite soft while below a couple of small breaks seemed to be present. The sand was shot with a heavy charge—about 100 quarts—and a 5-barrel well secured. The company next drilled Martin No. 3, about 1,400 feet due west of No. 2 and on the same farm. It was completed early in July, 1910, and was shot with 60 quarts, but the only reward was a showing of oil and some gas, and it will, in all probability, be abandoned. A location has been made north of the oil well on the Jones farm, but the result cannot be forcasted.

The Columbus Hocking Coal & Iron Company has made two tests to the Clinton on its property in this township. The first was on the northeast quarter of Section 30 and was completed late in 1909. After having been shot with 60 quarts the well began producing at the rate of 35 barrels a day, and this was maintained until the middle of the following May when an accident occurred stopping the well. The second test of this company was located 1,700 feet southeast of the first one. It was completed in December, 1909, and after having been shot with 60 quarts of nitroglycerine began flowing about 75 barrels of oil a day. By July 20 of the ensuing year it was producing 50 barrels, thus demonstrating excellent staying qualities. The well has never been pumped, but flows quite regularly at intervals of four hours.

One additional well remains to be mentioned. This is on the farm of the Clancey heirs near the western edge of New Straitsville. It was drilled by the Ebenezer Oil & Gas Company and the Clinton sand was penetrated June 25, 1910. When visited the well had not been cleaned and connected with the tank, so its capacity was not determined. The density of the oil was 46° B. and the temperature 78° F.[1] The well head is 760 feet above sea level, and the Clinton sand, which was reached at a

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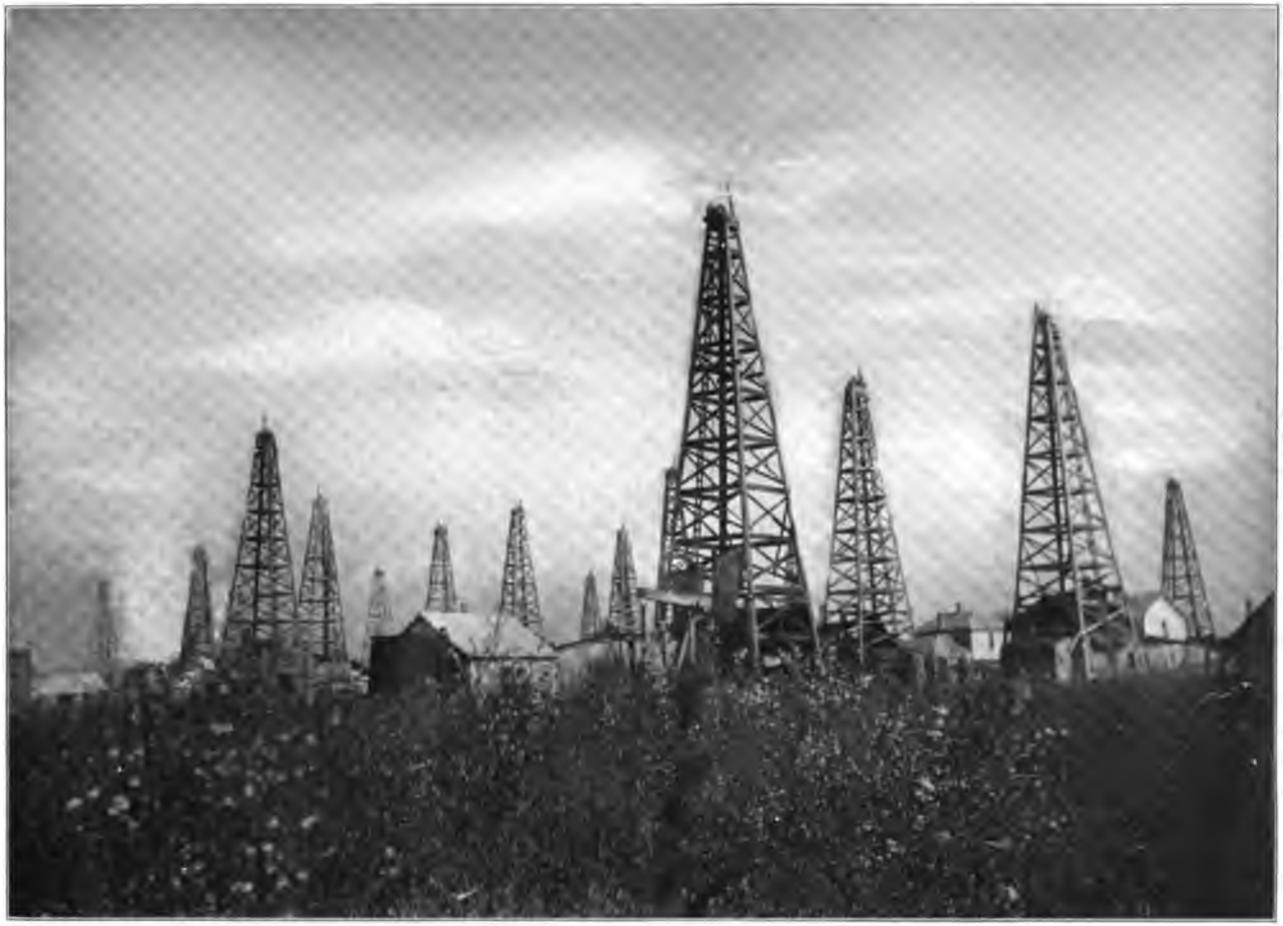
[1] For analysis of this oil see p. 17.

PLATE III.



The Crowding of Derricks Along the Southern Edge of Bremen.

depth of 3,106 feet, lies 2,346 below. Since this field was visited a well has been completed near the corporation line, the sand, about 25 feet thick, having been struck at a depth of 3,129 feet. It began producing oil at from 30 to 40 barrels a day.

The Clinton sand in this pool is persistent and quite thick. Its color is usually gray and its texture varies from well to well. Little or no water occurs in the sand, but it is abundant in the "Big lime."

Acknowledgment is made to Hon. E. S. Martin, of New Straitsville, for the facts pertaining to this pool.

Production of the Field.—This is shown by the following which has been provided by the Buckeye Pipe Line Co., Macksburg Division. As will be seen the production has risen irregularly to May, 1910, when the maximum was reached. Less drilling and hence fewer new wells since that time are responsible for the decrease. The indications are that the output will continue to shrink for months hence, and it may be that the productionof May last will not again be equaled.

PRODUCTION BY MONTHS.

August	1907	1,245.08	
September	1907	1,186.98	
October	1907	1,515.48	
November	1907	4,810.72	
December	1907	7,940.13	
			16,698.39 Barrels.
January	1908	14,263.35	
February	1908	14,292.30	
March	1908	18,082.39	
April	1908	18,377.23	
May	1908	24,002.01	
June	1908	29,542.68	
July	1908	33,749.72	
August	1908	38,849.75	
September	1908	33,815.16	
October	1908	31,335.44	
November	1908	29,561.17	
December	1908	36,280.90	
			322,152.10 Barrels.
January	1909	33,086.44	
February	1909	30,970.54	
March	1909	38,420.87	
April	1909	39,324.70	
May	1909	42,163.97	
June	1909	58,182.32	
July	1909	65,289.10	
August	1909	77,892.90	
September	1909	96,287.54	
October	1909	109,473.33	
November	1909	104,583.97	
December	1909	103,608.09	
			799,283.77 Barrels.

January	1910	120,524.22	
February	1910	119,172.23	
March	1910	152,223.95	
April	1910	171,413.42	
May	1910	184,544.11	
June	1910	164,814.51	
July	1910	147,473.80	
August	1910	148,822.76	
September	1910	134,172.88	
			1,343,161.88 Barrels.

Grand total........................2,481,296.14 Barrels.

Composition of Oil.—This has been determined by the United States Geological Survey, in co-operation with the Geological Survey of Ohio. A representative of the latter organization collected the samples and had them delivered at Washington, where the analytical work was done. All samples were taken directly from the well and then soldered. The results may be found on page 17.

Commenting on these analyses, Dr. David T. Day, of the United States Geological Survey, says: "The analyses of the Clinton oils submitted herewith show them to differ in no respect from the characteristic southwestern Pennsylvania oils and the light oils of West Virginia. They are characteristic Appalachian oils, yielding, as usual, considerable amounts of gasoline and a large percentage of illuminating oil. It is a curious circumstance that the dark green oil No. 3 should yield more gasoline than the light amber oil, which has evidently been filtered more thoroughly through dry shales. The great similarity between these oils and those of Pennsylvania and West Virginia is shown by the considerable proportion of paraffin wax and the low percentage of unsaturated hydrocarbons in the crude oil and in the burning distillate. It is hoped that in a short time further distillation of these oils can be made, by which the quality of the individual hydrocarbons may be estimated."

The Engler method for the distillation of samples of petroleum consists of very definite conditions for a fractional distillation in which the size of the flask, the rate of distillation, and in general all the manipulation processes are very specifically described.

The fraction designated as "To 150° C." includes the benzine and gasoline fraction or crude naphtha of the trade.

The fraction "150°-300°" includes the burning oil distillate or kerosene.

The fraction "Residuum" includes heavy lubricating oils, paraffin oils, etc.

The columns headed "Unsaturated Hydrocarbons" represent the portion of the oil that is removed by treatment with sulphuric acid in the process of refining.

ANALYSES OF OILS FROM THE CLINTON SANDSTONE.

Collected by	Date of Collection.	Serial Number.	Location of Well.	Depth to Sand.	Physical Properties.				Distillation by Engler's Method.								Sulphur.	Paraffine.	Asphaltum.	Water.	Un-saturated Hydro-carbons.	
					Gravity.		Color.	Odor.	Begins to boil °C.	By Volume.											Crude.	150–300 °C.
										To 150°C.		150–300°C.		Residuum.		Total						
					Specific.	Beaume.				C. C.	Sp. gr.	C. C.	Sp. gr.	C. C.	Sp. gr.	C. C.						
																	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
J. A. Bownocker	6–30–10	1	Fairfield Co., Bremen Coal, L. Groves well, No. 1.....	2.462	.7848	48.4	Green	Usual odor of Pennsylvania oils.	68	15	.7036	40	.7698	42	.8557	97	Not more than trace.	8.33	None.	None.	11.6	4
J. A. Bownocker	7– 6–10	2	Vinton Co., Jackson Township, Clinton well No. 1..	2.480	.7959	45.9	Light Green		102	4	.7140	51	.7673	43.6	.8600	98		5.62			5.6	4
J. A. Bownocker	7–12–10	3	Fairfield Co., Pleasantville Pool, Ruff well No. 2....	2.345	.8046	44.0	Dark Green		96	10	.7195	43	.7751	45.8	.8647	98.8		5.36			10.	4
J. A. Bownocker	7–16–10	4	Perry Co., Crooksville, Ohio, Fuel Co., well No. 1	3.407	.8014	44.7	Light Amber		98	7	.7215	45	.7736	45.6	.8663	97.6		6.63			10	4
J. A. Bownocker	7–20–10	5	Perry Co., New Straitsville Pool, Clancey well No. 1	3.106	.7923	46.7	Amber		80	17.5	.7141	33	.7753	45.7	.8706	96.2		8.30			10.8	6
J. A. Bownocker	8– 3–10	6	Knox Co., Bladensburg Pool McKee well............	2.771	.8469	35.3	Dark		75	14.0	.7201	26	.7973	52.1	.9063	92.1	Not determined.	4.17		Much	19.6	7

GEOLOGY OF THE BREMEN FIELD.

The territory is drained by Rush Creek and its tributaries, chief of which is North Fork. The valleys attain a maximum width of nearly a mile, and are very flat and usually poorly drained. The uplands vary from gently rolling to hilly; the Pleasantville pool illustrates the former and all others, outside of the valleys, the latter. In the western part of the field the surface rocks belong to the Mississippian (Lower Carboniferous), while farther east they lie in the Pennsylvanian (Coal Measures). Everywhere they consist essentially of sandstones and shales.

The surface rocks in the western part of the field lie at about the stratigraphical horizon of the "Big Injun" series which is so important a source of oil in the extreme southeastern part of Ohio and in West Virginia, but is void of both oil and gas in the Bremen field. The Berea sandstone is everywhere found at its proper horizon and occasionally makes a show of oil or gas. At Goble's station, near Junction City, several wells in this formation supply fuel for a brick yard and at Corning the rock has yielded oil in a commercial way for nearly 20 years.[1]

Well Records.—The thickness of the Clinton sand, its dip and position with reference to overlying formations, and the varying thickness of the latter are shown by well records. Starting in the Pleasantville pool and running southeast to McCuneville, near Shawnee, a distance of seventeen miles, conditions were found as follows:

Pleasantville pool; Ruff well No. 2, southeast quarter of Section 18; well head 975 feet above sea level:

	Thickness. Feet.	To bottom of formation. Feet.
Drive pipe	175	175
Berea sand	25	610
Casing 6¼ inch., 610 feet.		
Bedford and Ohio shales	880	1,490
Big lime	710	2,200
Casing $5\frac{3}{16}$ inch., 2,211 feet.		
Clinton sand	41	2,364
Gas at 2,331 feet.		
Oil at 2,339 feet.		
Total depth		2,368

This well produces oil in paying quantity, but so little water that it is a question whether any exists in the sand.

Kennedy No. 1, in valley of Rush Creek, near the station Rushville, well head 860 feet above sea level. Authority, S. W. Friesner, West Rushville, Ohio:

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[1] Bownocker, J. A. *Geol. Surv. of Ohio*, Fourth Ser., Bull. I, pp. 257-265.

	Thickness. Feet.	To bottom of formation. Feet.
Drive pipe, 8 inch	37	37
Berea sand	35	667
Casing $6\frac{5}{8}$ inch, 667 feet.		
Bedford and Ohio shales	990	1,657
"Big lime"	750	2,407
Casing 5 $\frac{3}{16}$ inch., 2,229 feet.		
Clinton sand	32	2,483

This well, which is situated two and one-half miles nearly due southeast of the preceding one, shows a thickening of 110 feet in the shales lying between the Berea and "Big lime" and 40 feet in the "Big lime" itself. In the Ruff well the Clinton sand is 1,348 feet below sea level and in the Kennedy, 1,591, a drop of 243 feet, or 97 to the mile. This well produces gas.

The next well is Householder No. 1, on Section 2 in the Bremen pool; well head 835 feet above sea level. Authority, W. S. Turner, Bremen, Ohio.

	Thickness. Feet.	To bottom of formation. Feet.
Drive pipe	49	49
Berea sand	....	710
Bedford and Ohio shales	975	1,685
"Big lime"	790	2,475
"Big water" at 2,185 feet.		
Clinton sand	34	2,619
Bottom of well	....	2,620

This well, which is $3\frac{2}{3}$ miles southeast of the Kennedy, shows a decrease of 15 feet in the thickness of the Bedford and Berea shales and an increase of 40 feet in the "Big lime." The top of the Clinton sand lies 1,750 feet below sea level, a drop of 159 feet from the Rushville well, or more than 43 feet per mile. As stated elsewhere the Householder began flowing 250 barrels a day.

Continuing southeast the valley of Rush Creek is reached at Flagdale, where the following record was secured from well No. 8, T. L. Griggs farm; elevation of well head 805 feet. Authority, Schrier and Kerr:

	Thickness. Feet.	To bottom of formation. Feet.
Mantle rock	55	55
Drive pipe 10 inch, 56 feet.		
Big Injun sand	100	235
Berea sand	33	718
Casing 8 inch, 720 feet.		
Bedford and Ohio shales	1,032	1,750
"Big lime"	798	2,548
Casing $6\frac{1}{2}$ inch, 2,425 feet.		
Clinton sand	33	2,708
Total depth	....	2,717

This well is about 2½ miles southeast of the Householder and shows an increase in thickness of the "Big lime" of 8 feet; in the Bedford and Ohio shales of 57 feet, and a drop in the position of the Clinton sand of 120 or 48 feet to the mile. It produces oil in commercial quantities.

One more record is needed to complete this section within the limits assigned, and that is at McCuneville. The well head is 797 feet above ocean level, and the record provided by L. C. Laube follows:

	Thickness. Feet.	To bottom of formation. Feet.
Drive pipe 17 inches	17	17
Through salt sand at 370 feet	....	......
Casing 10 inch, 370 feet.		
Berea sand	15	850
Bedford and Ohio shales	1,245	2,095
"Big lime"	870	2,965
"Big water" at 2,755 feet.		
Lime and shells at 3,094 feet.		
Clinton sand	32	3,148
Bottom of well, 3,165 feet.		

In comparison with the well at Flagdale this shows a thickening in the Bedford and Ohio shales of 213 feet; the "Big lime" of 72 feet, and a drop in the place of the Clinton sand of 449 feet or 52 feet to the mile.

For the sake of ready reference the dips of the sand are grouped together:

Pleasantville Pool to West Rushville	97	feet per mile
West Rushville to Householder well	43	" " "
Bremen Pool to Flagdale	48	" " "
Flagdale to McCuneville	52	" " "
Average dip	57	" " "

These figures show a varying dip, the greatest to the northwest and the least near the middle. It will be noted that they do not indicate an anticline—a structure that many geologists and prospectors regard as essential to oil or gas in marketable quantities. Plate IV shows diagrammatically these features and others of interest.

To show the changes in the formations along an east-west line a number of records from Lancaster to the vicinity of New Lexington will next be given.

Well drilled in 1886 in valley of Hocking River at Lancaster; elevation 812 feet. Authority, Edward Orton:

	Thickness. Feet.	To bottom of formation. Feet.
Drift	132	132
Cuyahoga and Sunbury shales	268	400
Berea sand	20	420
Bedford and Ohio shales	630	1,050
"Big lime"	700	1,750
Clinton sand at about 1,955 feet.		

The next record is that of Morrow No. 1 at Berne, 5½ miles east of Lancaster; elevation of well head 815 feet. Authority, The Logan Gas & Fuel Company.

	Thickness. Feet.	To bottom of formation. Feet.
"Big lime"	710	2,150
Clinton sand	35	2,298

These two records show a thickening of the "Big lime" of 10 feet, and a dip of the Clinton sand of 305 feet or 55 feet to the mile. Both were gas wells, the first small, while the second started flowing at the rate of 1,250,000 cubic feet per day.

Three and one-half miles east brings us to Bremen, where the underground succession is well known. Rodafer well No. 13 at edge of village; elevation of well head 800 feet. Authority, Schrier & Kerr:

	Thickness. Feet.	To bottom of formation. Feet.
Mantle rock	40	40
Casing 8 inch, 43 feet.		
Berea sand	25	650
Casing 6½ inch, 655 feet.		
Bedford and Ohio shales	935	1,585
"Big lime"	770	2,355
Heavy flow of water at 2,115 feet	....	2,115
Clinton sand	30	2,488
Bottom of well 2,493 feet.		

Here the "Big lime" is 770 feet thick, an increase of 17 feet to the mile, while the Clinton sand lies 1,658 feet below sea level, an increase of 210 feet or a dip of 60 feet to the mile.

The next record is Welch No. 8, northeast quarter of Section 19, Jackson Township, Perry County, two miles south of Flagdale; elevation of well head 864 feet. Authority, J. J. Klise:

	Thickness. Feet.	To bottom of formation. Feet.
Drive pipe	35	35
Berea sand	40	800
Casing 8¼ inch, 800 feet.		
Bedford and Ohio shales	1,060	1,860
"Big lime"	780	2,640
Casing 6⅝ inch, 2,544 feet.		
Cave from 2,640 to 2,774 feet.		
Clinton sand	31	2,805
Pay rock 2,789 to 2,774 feet.		
Bottom of well, 2,805 feet.		

This well began producing oil at the rate of 25 barrels a day. It is 4 miles east of Bremen and shows an increase of 10 feet in the "Big lime" and 125 feet in the Bedford and Ohio shales. Wells in this vicinity show that the surface of the Clinton sand is gently rolling, but no relation was found between the elevations and depressions and the production of oil.

The last of this group of records is on the Lefever farm, Section 13 of Pike Township, three miles south of east of New Lexington; elevation of well head 831 feet above ocean level. Authority, J. J. McGonagle:

	Thickness. Feet.	To bottom of formation. Feet.
Conductor	17	17
Flow of water at 62 feet.		
Berea sand	15	960
Casing $6\frac{5}{8}$ inch, 960 feet.		
Bedford and Ohio shales	1,345	2,305
"Big lime"	800	3,105
Heavy flow of water at 2,993 feet.		
Casing $5\frac{3}{16}$ inch, 3,290 feet.		
Shales	195	3,300
Clinton sand	35	3,335

The sand was of poor quality and was without oil or gas. This well is 10 miles east and one mile north of Welch No. 8, and shows a thickening in the Bedford and Ohio shales of 285 feet and in the "Big lime" of 20. The Clinton sand is 2,469 feet below sea level, a drop of 559 or 59 feet to the mile.

As a summary it may be stated that from Lancaster to the Lefever well southeast of New Lexington, a distance of 23 miles, the Bedford and Ohio shales have increased 715 feet in thickness, an average of 31 feet to the mile; the "Big lime" has thickened 100 feet or more than 4 feet to the mile, and the Clinton sand has dipped 1,326 feet, an average of 57 per mile. It should be noted that the dip of the sand does not vary greatly, as the following summary shows:

Lancaster to Berne	55 feet per mile.
Berne to Bremen	60 feet per mile.
Bremen to Welch No. 8	63 feet per mile.
Welch No. 8 to Lefever No. 1	56 feet per mile.

These figures not only do not show an anticline, but the larger dip in the vicinity of Bremen and the Welch well indicates rather the reverse. The structure of the sand may be likened to a very shallow basin tipping to the east and south. Pools usually show low folds with intervening depressions, but oil was found in both places.

Having shown the changes in the principal formations to the east and southeast, a record will next be given of a well in the New Straitsville pool; this is Martin No. 3. Authority, Hon. E. S. Martin:

	Thickness. Feet.	To bottom of formation. Feet.
Drive pipe	50	50
First water at 75 feet.		
Second water at 380 feet.		
Berea sand	20	940
Bedford shales (red)	60	1,000
Ohio shales Black, 20 ft "Little Cinnamon," 30 ft. "Big Cinnamon," 25 ft.	1,170	2,170
"Big lime"	820	2,990
Clinton sand	17	3,192
Bottom of well 3,213 feet.		

The elevation of this well head was not determined, but that of the Clancey heirs is 760 feet. The oil sand in that was reached at a depth of 3,106 feet and therefore lies 2,346 feet below ocean level. This is a drop of 212 feet from Junction City and 688 feet from Bremen.

The Clinton Sand.—This is unique in that it nowhere outcrops in the State. Not that the associated strata fail to rise to the surface, for they may be seen in a broad belt extending from Preble to Adams Counties in the southwestern part of the State. The sand in question, which nowhere has been reported more than 102 feet thick in Ohio, thins rapidly to the west and disappears before the longitude of the Scioto River is reached. At any rate, no wells that far west have reported the Clinton sand. Wells in such places record nothing but shales between the base of the "Big lime" and the red rock usually called Medina.

The sand has not been reported farther south than Washington Township, Jackson County, but its horizon has not been reached farther south, with the exception of Mt. Vernon and Ironton, Lawrence County, where no sand was found.[1] To the north it has been traced to Lake Erie, and is there a source of gas in commercial quantities. Eastward it has been found in Olmsted Township, Cuyahoga County, and at Wooster. In central Ohio it has not been reported farther east than Muskingum County, and in Crooksville and near Roseville in eastern Perry County. There is no reason to believe however, that the sand is not present farther east, but its depth is such that the drill has not penetrated it. Facts will later be stated concerning the sand in the Vinton, Knox, and Richland County pools, and it remains now to state the record for the Bremen field. Later, the many tests in territory that has not proven a source of oil or gas will be reviewed.

Like most sands, the Clinton has no characteristics that serve to distinguish it from others, and few men with experience would be so rash as to say whether a given hand specimen is Clinton or not. Commonly the color is gray, but the shade may change to brick-red, and both may be a source of oil. Especially is this true near Bremen, but in all directions from that village the red color usually fades away. The rock is commonly fine-grained and compact. Anyone basing his knowledge of oil sands on the coarse open-textured varieties represented by the Cow Run and Big Injun would look with scant favor on the Clinton. Wells generally make a poor showing until after being shot, indicating a compact sand.

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[1] Tests have also been made near Oak Hill, Jackson County and Vinton, Gallia County, but neither reported the Clinton sand.

The sand in the Bremen field is persistent, rarely wanting. Twenty wells selected at random in the Bremen pool showed thicknesses ranging from 4 to 38 feet, with an average of 29 feet. Those in the New Straitsville pool found the sand more uniform, varying from 17 to 38 feet and averaging 27 feet. Wells near Junction City give similar results, and this is true also in the Pleasantville pool.

In no other oil rock in Ohio are similar conditions found with reference to salt water. Generally an oil well pumps several times as much brine as oil, but in the Clinton sand—everywhere in Ohio—the reverse is true. Some of the drillers of wide experience maintain that the rock is free from water and that the little occasionally found has worked down from the "Big lime." Others take the view that the sand in places contains a small quantity of water. Considering the small volume found and that some wells pump none at all, as well as the chances for water to work down around the casing or through leaky joints, leads the writer to the conclusion that the sand is normally free from water when first penetrated by the drill.

The closed or rock pressure of gas wells is commonly regarded as due to the weight of a column of water; that is, to hydrostatic pressure. Occasionally gas wells in the Bremen field register 700 pounds or even more to the square inch, and yet the fuel comes from a formation that is free or nearly so from water and that is imbedded in shales that are impervious. The same is true in the great gas fields of Central Ohio. These facts demonstrate that water is not the cause or even a factor in the rock pressure of gas in the Clinton sand.

The dip of the sand has been indicated on preceding pages and is shown on Plates IV and V. Gas, when found, is nearly always in the higher parts of the formation, that is, along its western border, and oil at greater depth to the east. It is a common theory that oil rests on the surface of salt water and rises or falls with this liquid. That cannot apply in the Bremen field for the reason little or no brine is present, and it is a reasonable assumption that the oil accumulates in the depressions where the Clinton sand is sufficiently open textured to store it.

Shales between the Clinton Sand and the "Big lime".—The position of the oil rock with reference to the "Big lime" varies from pool to pool and to a smaller extent from well to well. In that part of the Bremen pool first drilled, five wells selected at random showed intervals ranging from 113 to 140 feet with an average of 126. In the valley of Rush Creek near Flagdale six wells gave figures varying from 117 to 142 feet, an average of 128. Near the village of Bremen the interval is less, seven wells showing variations from 88 to 115 feet and averaging 103. At New Straitsville, farther south, the interval is bly larger, five wells averaging 171 feet.

his interval is occupied by shales with occasional thin layers of shaly limestone, known as shells among drillers. A workman of large experience in the Bremen pool gave the succession as follows:

Base of "Big lime"	Feet.
Shales, lead color	55
Shales, green color	30
Shales and shells	20
Shales, red	5
Top of Clinton sand.	

Following is a partial record from a well near Sugar Grove, samples of the drillings having been collected by the writer:[1]

Base of the "Big lime."	Feet.
Shales, light chocolate color; some lime	36
Shales, green and chocolate colors, the latter fossiliferous; some lime	31
Shales, green and chocolate colors; much lime	37
Top of Clinton sand.	

Doubtless the shales vary somewhat in color as in other properties, from well to well. The red band reported in the Bremen pool is quite persistent and is one of the guides to the driller. It has been confused with the red shales lying below the Clinton and commonly known as Medina. In such cases the driller concludes that he has passed the horizon of the desired sand, when in fact he has not reached it.

The "Big lime."—In nearly every oil and gas field some formation or formations exist to serve as a guide to the driller. Thus in the shallow sand territory of Morgan, Noble and Washington Counties, the Ames or Crinoidal and the Cambridge limestones serve in this capacity. Farther east the "Big lime" is the great guide. This name is used for another formation already referred to a score or more times in this bulletin, and it is very important that the two be not confused.

The "Big lime" of southeastern Ohio is the Maxville limestone of this State and the Greenbrier of West Virginia. It forms the summit of the Mississippian (Lower Carboniferous) rocks and hence lies high above the "Big lime" of the Clinton fields which represents the lower part of the Devonian and nearly the whole of the Silurian (Upper Silurian).

The Maxville or "Big lime" attains a maximum thickness of 110 feet in Ohio, but thins rapidly to the northwest and is seldom reported by the driller beyond the middle of Washington and Monroe counties. Occasionally it has a little oil or gas, but the formation is not rated as one of the commercial sources of either of these fuels. Imbedded in rocks, otherwise without limestone, it serves admirably as a guide to the driller. Interesting to report, this formation lies above drainage in parts of Muskingum County and others to the southwest. It was named from Maxville Perry County, where a fine exposure may be seen.

The "Big lime" of the Clinton sand territory lies much lower in the geological column and comprises nearly the whole of the Silurian (Upper

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[1] Bownocker, J. A. *Geol. Surv. of Ohio,* Fourth Ser., Bull. I, p. 118.

Silurian) and the lower part of the Devonian. The relative positions of the two "Big limes" are shown below:

Mississippian (Lower Carboniferous)	Maxville limestone	*The "Big lime" of Southeastern Ohio.*
	Logan group	Keener sand. Big Injun sand. Squaw sand.
	Berea sand.	
Devonian	Ohio shales.	
	Delaware limestone	*"Big lime" of the Clinton sand fields.*
	Columbus limestone	
Silurian	Monroe or "Lower Helderberg" limestone	
	Niagara limestone	
	Clinton limestone	

As is well known, the Columbus and Delaware formations outcrop as a narrow strip from Pickaway County north to Lake Erie, while the remaining members of the "Big lime" are found at or near the surface over much the larger part of the western half of the State.

In thickness the formation varies in different parts of Ohio. Its greatest measurement was at Newburg near Cleveland where it is about 1,700 feet, but according to Orton[1] 800 feet of this belongs to the Salina, a formation that is wanting in central and southern Ohio. Westward it thins, measuring 1,325 feet near Avon, Elyria County, and 1,150 feet at Sandusky. Abundant figures and illustrations have already been given to demonstrate its variation in thickness in Central Ohio. Passing south from Lake Erie the formation again thins. It measures 1,100 feet in Jackson Township, Ashland County; 863 feet near Bladensburg, Knox County; 817 feet near Claylick, Licking County; 780 feet at Bremen; 725 feet at Logan; 590 feet in northern Jackson County, and 584 feet at Ironton on the bank of the Ohio River. These facts are shown diagrammatically on Plate VI.

In the Bremen field the "Big lime" is fairly uniform in character. Rarely or never is it broken by shales; in other words, it is a massive formation or rather group of formations, all of limestone. Drillers speak of the top 150 feet as "gritty" and hard to drill. Occasionally it shows a little black oil. Water is found in it at various depths and in varying quantities; near Bremen the heaviest flow is found at about 550 feet. It may fill the hole or when the flow is light may be controlled with the bailer. Where the water is abundant the rock drills easily, indicating a very porous structure. Near its base the "Big lime" is reported of a darker color, softer, and occasionally streaked with shales.

The Survey is indebted to Mr. J. J. McCarten, of Bremen, for an excellent set of drillings from Holliday well No. 8, Section 12, of Rush

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[1] Orton, Edward. *Geol. Surv. of Ohio*, Vol. VI, p. 356.

Creek Township, Fairfield County. Thirty-three of the samples are from the "Big lime," and on the basis of chemical composition and physical properties they may be classified as follows:

Columbus limestone. 50 feet. Calcareous. Gray color.

Monroe limestone. 275 feet. Magnesian. Dark gray color, contrasting in this respect sharply with the Columbus limestone. Some gypsum at from 125 to 200 feet in the formation.

Niagara limestone. 360 feet. Magnesian. Light gray color changing to brown in lower part. Drillings fine, resembling sand grains. These drillings in size and color make a sharp contrast with those of the Monroe limestone.

Clinton limestone. 95 feet. Calcareous. Dark gray at top, changing to various tints below with slate color at base.

In the vicinity of Sugar Grove a layer of sand is occasionally reported in the "Big lime" and may yield a good flow of gas. The same condition has been found in Ashtabula County,[1] while in Lucas County a sandstone in the Monroe limestone ("Lower Helderberg") has long been quarried for making glass. As the "Big lime" is followed north and south from Bremen it shows little change, except in thickness, until the northern counties are reached, when rock salt appears. The latter point will be referred to again in the review of Wayne, Medina and Lorain counties.

The Ohio Shales.—This great formation and the Bedford shales—the latter lying immediately below the Berea sand—occupy the great interval between the latter and the "Big lime." Quite commonly the Bedford has a red color, and then may easily be distinguished from the Ohio shales, but when the color is that of slate, or dark gray, green or black, the usual colors of the Ohio shales, it is difficult or impossible for the driller to determine where the Bedford terminates below. These shales outcrop along the shores of Lake Erie almost as far west as Sandusky, and from there south across the state to the Ohio River. The Ohio shales have been described in our State reports for the past forty years, and nothing more than the salient features will be attempted here. As is well known, they consist of shales only, but along the Ohio River in the eastern part of the State they have been reported,a very few times, to contain a thin bed of sandstone, the western extension of one of the oil bearing rocks of Pennsylvania. Their color varies from dark gray, through green to black, and the texture is that of clay. In other words, they are composed of aluminous particles rather than sand. Their composition varies rapidly, horizontally as well as vertically, and this has operated against their use in the manufacture of clay products. Concretions of various kinds are abundant, and constitute the most important structural feature of the formation. The most striking feature, however, to the driller for oil or gas has already been specifically pointed out, and will simply be mentioned here; the shales thicken to the east and south, and hence increase the interval between the Berea sand and the "Big lime." At McConnelsville, on the Muskingum River, they measure 1,739 feet. The variations from the lake to Ironton have already been shown on Plate VI, and further consideration of that matter will not be given here.

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[1] Bownocker, J. A. *Geol. Surv. of Ohio,* Fourth Ser., Bull. I, p. 303.

The importance of these variations and those of the "Big lime" are of the first grade to the driller. It increases the dip of the Clinton sand, and hence its depth, limiting the territory in which it is accessible. Along the Ohio River in eastern Ohio, the shales may be 3,000 feet thick, and manifestly the Clinton sand is at such a depth that it cannot be a commercial source of fuel. In the vicinity of Zanesville this formation is reached at a depth of 3,543 feet,[1] and in the writer's judgment this is about the maximum depth to which drilling will extend in Ohio under existing conditions.

The Ohio shales have long been a source of gas along the lake shore. Usually a well supplies heat and light for a residence, and occasionally for several, but the supply is never large. The gas is not found at any one horizon, and hence the depth varies. In central Ohio the shales contain less fuel, and these are not a source of gas in a commercial way. In Pennsylvania this great formation contains a number of important oil and gas rocks, such as the Bradford, McDonald and Gordon sands. Westward these thin and disappear, or practically so, by the time the Ohio River is reached. Many wells for one or the other have been sunk in eastern Ohio, but the result in every case has been failure.

The Berea Sand.—This is the last formation in the ascending column that will be considered, and only a few sentences will be given to it. The formation outcrops in much the same way and places as the Ohio shales. It is very persistent, and has been penetrated by the drill in every county where due, and in many of them scores of times. Well records already given and those which follow show its thickness in many counties. Farther east and south it is thinner, but nearly always present. As is well known, it is a valuable source of oil and gas in Jefferson, Belmont, Washington, Perry and other counties, and in eastern Ohio is the lowest available source of these fuels.

Formations Below the Clinton Sand—These are well shown for this part of the state by the following well record: Crouse Well No. 1, Section 32, Pleasant Township, Fairfield County; completed August 19, 1907. Authority, B. S. Stretton:

	Thickness. Feet.	To bottom of formation. Feet.
Drive pipe	41	41
Casing 6½ inch, 605 feet.		
"Big lime" top at 1,378 feet.		
Casing 5 inch, 2,044 feet.		
Clinton sand	5	2,185

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[1] For well record see p. 35.

			Thickness. Feet.	To bottom of formation. Feet.
Medina (?) shales.	red	8 feet.	284	2,500
	blue	76 feet.		
	pale red	90 feet.		
	green	40 feet.		
	red	70 feet.		
	blue	75 feet.	970	3,470
	slate and shells	100 feet.		
	white shells	90 feet.		
	dark	28 feet.		
	shells	90 feet.		
	harder shales	121 feet.		
	black shells	35 feet.		
	white shells	12 feet.		
	dark shells	27 feet.		
Ordovician shales.	blue at	2,224 feet.	207	3,470
	pale red at	2,300 feet.		
	green at	2,390 feet.		
	red at	2,430 feet.		
	blue at	2,500 feet.		
	slate and shells (100 ft.)	2,575 feet.		
	white shells at	2,675 feet.		
	green at	2,765 feet.		
	dark at	3,078 feet.		
	shells at	3,106 feet.		
	shells at	3,196 feet.		
	black shells	3,396 feet.		
	light shells at	3431 feet.		

Trenton limestone at 3,470 feet.
Bottom of well at 3,569 feet.

This shows an interval of 1,285 feet between the Clinton and Trenton. At Amanda, approximately ten miles to the southwest, the same interval measures 1,193 feet. Persons desiring the thickness of the Trenton and information on the formations below it should consult the record of the test at Waverly on page 48.

METHOD OF DRILLING.

This varies but little from other deep sand territory in the Appalachian field. At first the wells were drilled "wet"—that is, casing was inserted at the base of the Berea, and none other was used until the Clinton sand was reached. As already stated, heavy flows of brine were found in the "Big lime," especially at from 500 to 600 feet in that formation, and that greatly retarded the progress of the drill by its buoyant action on the hemp cable. This objection, however, was later overcome by using a wire cable in place of hemp from the water down. At present the casing is hung on a disc packer which is usually set just below the place of the heavy flow. In other words, the casing is hung in the well rather than placed on the Clinton sand. The long column of water may crowd the oil away from the hole, thus diminishing the production, and may enter the sand, producing possible evil effects.

These difficulties may be overcome by drilling "dry." In this method casing is set just below the Berea, and another string below the heavy flow of water in the "Big lime." Sometimes several flows are found and it may be necessary to recase each time, adding materially to the labor. Worse still, the shales lying above the Clinton sand cave badly, necessitating a liner between that formation and the base of the "Big lime." This increases the difficulty in shooting, for when the shot is placed and the liner drawn, a cave follows and may cause difficulty in discharging the shot. This is usually met by placing a loaded anchor of such length that it extends above the cave. Perhaps one-half of the wells in the Bremen field have been drilled "dry." In drilling "wet" little or no cave takes place, the weight of water apparently keeping the shales in position.

In this method hemp cables are used, but when drilling "wet" wire replaces the hemp as soon as a heavy flow of water is found in the "Big lime." Friction with the rough walls of the hole soon destroys this cable, but the pieces may later be used in pumping wells. Derricks 80 feet high are used. Nearly all are wood, but steel has made its appearance and may be the reliance of the driller in the future. It is more expensive, the cost being about $900 against $725 for wood.

The expense and time necessary for drilling a producing well naturally varies with the depth and the freedom from accidents. For the territory in the valley at Bremen it is about as follows:

Derrick (wooden)	$725
Drilling 2,450 feet at $1.10	2,695
Conductor 80 feet at 70 cents	56
Casing to base of Berea 650 feet at 55 cents	358
Casing to Clinton, 2,450 feet at 45 cents	1,102
Tubing 2,460 feet at 15 cents	369
Pumping outfit	250
Gas engine and belt for pumping	850
Two tanks	225
Tank house	100
Lead lines, etc	100
Total	$6,830

If the well is dry the expense is approximately as follows:

Drilling	$2,698
Moving rig	200
Conductor	56
Total	$2,951

It will be noted that allowance is not made here for the wear and tear on materials used. This will increase the expense to about $3,500. With good luck, such a well may be completed in 30 days from the time drilling begins.

CHAPTER II.

THE SEARCH FOR THE CLINTON SAND EAST AND SOUTH OF THE BREMEN FIELD.

The search for the Clinton sand in Southern Ohio has been in progress twenty years. The formation has not been found farther south than Jackson County, though tests have extended to the bank of the Ohio River.

PERRY COUNTY.

Many tests of the Clinton sand have been made in this county with the hope of extending the Bremen field, and while these in the main have been unsuccessful, they have occasionally found the desired fuel and may lead to important extensions.

Monday Creek Township.—About a score of Clinton wells have been drilled in this township, with but little success. The following record of the Perrill well at Maxville shows the succession of the important strata as far down as the Clinton:

	Thickness. Feet.	To bottom of formation. Feet.
Drive pipe	27	27
Fresh water at 250 feet.		
Berea sand	25	830
Casing 6½ inch, 840 feet.		
Bedford and Ohio shales	1,128	1,958
"Big lime"	810	2,768
Gas at 2,426 feet.		
Water at 2,442 feet.		
Clinton sand	33	2,973
Bottom of well 2,984 feet.		

This well was completed in July, 1909, and is reported to have begun producing 40 barrels of oil a day, and a year later about one-fourth as much.

The Columbus Hocking Coal & Iron Company has drilled a number of wells. One on the southeast quarter of Section 22 gave a moderate flow of gas which is piped four miles to Kachelmacher's brick yard and used in burning brick. Another well, drilled a few hundred feet to the south, was dry. The company drilled also in the southwestern corner of Section 11, but found only a shell of the desired sand; a depth of 3,565 feet was reached. A well in the southeastern corner of Section 13 was dry.

Other wells were drilled in this township as follows: a small oil well and a dry hole on the southeastern quarter of Section 4, and a dry hole along the western border of the section; two dry holes on Section 5, one on the southeastern quarter, and dry, and one near the northern line of the section, the latter making a showing of oil; a small oil well and a dry hole on Section 7, the former on the northwestern quarter and the latter on the southeastern; a dry hole on the northwestern quarter of Section 8; two wells on Section 9, an oil well that started at about 30 barrels on the northeastern quarter and a dry hole on the southeastern; a dry hole on the northwestern quarter of Section 10; a dry hole drilled by the Carter Oil Company on the northeastern quarter of Section 19, and a small oil well, drilled by the same company, and now abandoned on the same quarter of Section 20.

Salt Lick Township.—But one well has been drilled in this township, and that was about one-half mile west of McCuneville. The elevation of the well head is 797 feet above ocean level. The well was drilled by the Shawnee Oil & Gas Company, and the record, as furnished by L. C. Laube, may be found on page 20.

At 1,510 feet the drill struck a sandstone about one foot thick which contained a heavy black oil. The sand was shot with 8 quarts and the well pumped; it yielded five barrels the first day, three the second and then two a day for approximately two weeks. The driller calls this sand the Gordon. It lies in the Ohio shales and is probably of local extent only; at any rate it has not been reported elsewhere in Ohio. Not satisfied with the production, the tubing was drawn and the drill started for the Clinton. Work progressed favorably until the "Big water" was reached at 2,756 feet. Casing was inserted at about 2,800, and after pumping 2,600 feet of water from this, the hole was dry until 20 feet advance was made, when another heavy flow was encountered and the well filled to within 20 feet of the top. Again the casing was set and drilling resumed. Seven additional times heavy flows of water were found, and each time the casing was reset. The last flow was only 6 feet above the base of the "Big lime," and the casing was finally set 8 feet below the base of that formation. To add to the trouble the packer broke twice, necessitating drawing the casing each time, making 10 changes in all.

At a depth of 3,070 feet the well began caving and of course this delayed the work, but the liner was finally set on top of the Clinton sand. This formation was 32 feet thick and varied somewhat in color as follows:

	Feet.
Gray sand	12
White sand	1½
Pink sand	5
Lighter colored sand, gray near the bottom	13½

The next step was to shoot the well, for the sand made a showing of oil. Fifty quarts of nitroglycerine increased the production to such an extent that the bailer came up filled with the fluid and it was decided to shoot again. Accordingly a dump shot of 200 quarts and 100 feet of loaded anchor were placed in the well. The liner was then withdrawn, and after two unsuccessful efforts to discharge the shot, the line was run and a bridge found about 30 feet above the top of the anchor. On the following day the driller ran down the tools to remove the bridge, and after about ten minutes' work it gave way and discharged the shot. The tools were blown up about 300 feet in the hole and torn loose from the cable, but were removed without great difficulty. Next an effort was made to clean the well. As soon as the bottom of the casing was reached, water again appeared and could not be controlled. Thinking that the casing was leaking, it was again withdrawn, but found to be all right. Apparently the shoulder of Clinton sand on which it rested had been partly blown away, letting the water flow in below. Not knowing what to do, and completely discouraged, "the company plugged the hole, drew the casing, and quit."

Considering the large sum of money already expended, it may be asked if it would not have been worth while to try developing a new shoulder for the casing to rest on, after the manner in California. The hole could have been filled with cement to a little above the Clinton sand, and after setting redrilled, and the casing placed on top of the new shoulder. The expense of this experiment would have been small, and might have saved the well.

Pleasant Township.—At least two Clinton wells have been sunk in this township. In the spring of 1909 one was drilled on the McGonagle farm a half mile south of Moxahala. The well head was 832 feet above ocean level, and the Clinton sand was found 52 feet thick, but it contained not even a smell of oil or gas. About a year later the Penn Oil Company, of Pittsburg, drilled a well two miles south of Moxahala, on land of James Kelly, but it, too, was a failure.

This sand is remarkable for its thickness, 102 feet. So far as the writer knows, it is far and away the greatest yet reported for the Clinton in Ohio, and it is twice the usual maximum given. The sand is also notable for its coloring. In spite of the great quantity, it did not contain a trace of either oil or gas. Neither did the sand contain water, while the "Big lime" had so little that no casing was used below the Berea.

Harrison Township.—The survey has record of three Clinton wells in this township, which lies along the eastern edge of the county, and all produce oil or gas. They are the deepest successful wells yet drilled in Ohio. On November 10, 1909, a well was started on the farm of David Allen, Section 8 of Harrison Township, about two miles southwest of Roseville, and progress was such that the well was not completed until March 29, 1910. The well was drilled by Stretton & Cole, who have provided the following record:

	Thickness. Feet.	To bottom of formation. Feet.
Drive pipe 10 inch	40	40
Casing 8 inch, 550 feet.		
Casing 6½ inch, 920 feet.		
"Big lime"	955	3,280
Casing $5\frac{3}{16}$ inch, 3,240 feet.		
Clinton sand	44	3,476
Oil at 3,470 feet.		
Total depth 3,439 feet.		

This well started pumping about 15 barrels a day. though some have reported the rate as high as 25 barrels. When visited in July, 1910, it was out of order, and, in fact, does not seem to have been properly cared for. It is the deepest oil well in Ohio, and one of the deepest in this country.

A well was completed by the Ohio Fuel Supply Company in the valley at Crooksville in October, 1909, and is reported to have started producing gas at the rate of 2,000,000 cubic feet a day. Later an overflow of the creek flooded the well, and it had not been put in condition by July, 1910. The Clinton sand, 28 feet thick, was struck at 3,409. January 5, 1910, a well was completed by the same company one location from the above, and began producing ten barrels of oil a day, and six months later was making 15 barrels. The well was shot first with 60 quarts, and later with 200. When agitated it still flows (July 16, 1910). The well head is 760 feet above ocean level, and the Clinton sand was struck at a depth of 3,407. The sand is 54 feet deep; it contained a break at 3,422 feet, and 14 feet of pay beginning at 3,444.

A location has been made by the Sago Oil Company near the edge of the corporation, and probably by the time these lines are in print a third will have been drilled to the Clinton sand. To be profitable such wells must be at least fairly large, long-lived and dry holes few.

Reading Township.—This lies north of Jackson, one of the largest producers in the entire Bremen field, and has been tested at numerous places. In the northwest quarter of Section 32, seven wells have been drilled, of which three produce oil. In the southern half of Section 35, out of five wells drilled two oil producers were gotten. On land of the St. Joseph's Literary Society four gas wells have been secured in the southwestern quarter of Section 14. Well No. 2 on this property gave measurements as follows, the head being 1,025 feet above ocean level:

	Thickness. Feet.	To bottom of formation. Feet.
Drive pipe	30	30
Berea sand	75	1,015
Casing $6\frac{5}{8}$ inch, 1,060 feet.		
Bedford and Ohio shales	1,100	2,115
"Big lime"	817	2,932
Clinton { sand 34 feet shale 5 feet sand 20 feet }	59	3,128
Bottom of well at 3,130 feet:		

Occasionally a small oil or gas well has been secured elsewhere in the township, but the usual result has been a dry hole. The location of these is shown on Plate I.

The Northern Tier of Townships.—Less exploration has been done in these townships than farther south, and little has been found to reward the driller. About three years ago seven wells were drilled in the northwestern corner of Thorn Township, the result being three small gas wells and four dry holes. The following measurements are from the John Trovinger Well No. 1, on the southeastern quarter of Section 8:

	Thickness. Feet.	To bottom of formation. Feet.
"Big lime"	710	2,320
Clinton sand	20	2,480

Bottom of well 2,570 feet.

Four wells are reported from Hopewell Township. One along the eastern line of Section 11 produced some oil, but the well has been abandoned. The other tests were as follows: A dry hole along the eastern border of Section 17; a dry hole on the eastern side of Section 12 and one on the southeastern quarter of Section 24.

The only test of which the Survey has knowledge in Madison Township is on the southwestern quarter of Section 5. A flow of gas was secured, but apparently the result has not encouraged further drilling.

MUSKINGUM COUNTY.

Several Clinton wells have been drilled in this county, the first attempt having been made in 1884 following the excitement from the discovery at Findlay. The location was at Zanesville and a depth of 2,000 feet reached, but the Berea was without oil or gas and the drill did not even approach the horizon of the Clinton sand.

In 1903 The Chicago-Zanesville Oil & Gas Company made a test at Dillon's Falls in the valley of the Licking River a few miles above Zanesville, the record of which follows:

	Thickness. Feet.	To bottom of formation. Feet.
Berea sand	12	907
Bedford shales	21	928
Ohio shales	1,192	2,120
"Big lime" limestone 160 feet black shales 68 feet limestone 1,047 feet	1,275	3,395
Shales	88	3,483
Lime shell	6	3,489
Shales	11	3,500
Sandstone	3	3,503
Shales	12	3,515
Lime shell	7	3,522
Shales	21	3,543
Clinton sand	21	3,564
Blue shales	3	3,567

Small flows of salt water were struck at 2,560 and 3,205 feet, and a show of oil and gas in the Clinton at 3,562; the well was abandoned.

Quite recently three wells have been drilled on Sections 18 and 19 of Newton Township, near the village Fultonham, two of which produce oil and one gas. The latter is on land of W. J. Roberts, Section 18, and the former on farms of Mary E. Grimsley and Emily Moore, Section 19. The Grimsley well started producing 7 barrels per day, but after having been shot with 60 quarts increased to approximately 20 barrels. At date of writing the Moore well has not been completed and its production cannot be stated. Following is a record of the Roberts well:

	Thickness. Feet.	To bottom of formation. Feet.
Limestone	54	96
Shale	5	101
Limestone	19	120
Water at 75 feet.		
Sandstone	130	250
Limestone	38	288
Much water at 270 feet.		
Big Injun sand	224	512
Limestone	98	610
Berea sandstone	14	861
Water in Berea sand.		
Bedford shales	26	887
Casing 882 feet.		
Ohio shales	1,308	2,195
"Big lime"	970	3,165
Casing 5$\frac{3}{16}$ inch, 3,003 feet.		
Limestone shell	8	3,282
Clinton sand at 3,296 feet.		
Gas at 3,298.		
Total depth 3,314 feet.		

On May 21, 1909, the Zanesville Gas & Oil Company completed a well on the farm of George Handchsy, Section 25 of Perry Township, six miles east of Zanesville. The Clinton sand was struck at 3,705 feet and though 38 feet thick it did not contain a trace of oil or gas. For the following record of this well the survey is indebted to Mr. W. Hunter Atha of Zanesville.:

		Thickness. Feet.	To bottom of formation. Feet.
Berea sand		23	1,033
Bedford shales (red)		15	1,048
Casing 6 inch, 1,065 feet.			
Ohio shales	limestone .... 15 feet shale and lime shells .... 1,312 feet lime shells ...... 265 feet	1,592	2,640
"Big lime"		1,005	3,645
Much water at 3,486 and 3,544 feet.			
Casing 5 inch, 3,553 feet.			

	Thickness. Feet.	To bottom of formation. Feet.
Black shales	5	3,650
Lime shells	3	3,653
Shales	16	3,669
Sand shells	3	3,672
Shales	18	3,690
Red sandstone	4	3,694
Black shale	15	3,709
Clinton sand	38	3,747
Shales	58	3.805

In the autumn of 1910 two wells were being drilled in the northwestern part of the county, one in Jackson Township about three miles northwest of Frazeysburg, and one in Muskingum Township about two miles southeast of the hamlet Shannon.

In October, 1910, a well was completed on the Fairall land in the southwest quarter of Section 7 of Jackson Township, the record of which follows:

	Thickness. Feet.	To bottom of formation. Feet.
Drive pipe	28	28
Berea sand	16	850
Casing 6⅝ inch, 863 feet.		
Bedford and Ohio shales	1,185	2,035
"Big lime"	934	2,969
Casing 5$\frac{3}{16}$ inch, 2,844 feet.		
Shales	172	3,141
Clinton sand	21	3,160
Shales	24	3,194
Total depth of well 3,194 feet.		

This well is rated among the successful producers of oil, though its capacity has not been learned. A test is now being made in the northwestern quarter of Muskingum Township, but it has not reached the horizon of the Clinton sand.

While tests have thus far disclosed but little oil or gas in this county, they have proven the Clinton sand present in good thickness at widely separated intervals, and with this encouragement further drilling is certain.

MORGAN COUNTY.

In September, 1894, a deep well was begun at McConnelsville, the town council having provided $5,000 to meet the expense. Progress was slow. By the middle of the next March a depth of 3,186 feet was reached, and the tools having become fast the well was abandoned. Following is a record of this well:[1]

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[1] For a detailed record see Bownocker, J. A. *Geol. Surv. of Ohio* Fourth Ser., Bull. I, p. 145.

	Thickness. Feet.	To bottom of formation. Feet.
Surface materials	15	15
Shales, sandstones, clay and coal	610	625
Maxville limestone or "Big lime"	44	669
Keener sand	40	709
Big Injun sand	45	840
Cuyahoga shales	409	1,249
Sunbury (Berea) shales	30	1,279
Berea sand	66	1,345
Bedford sandstone and shales	25	1,370
Ohio shales	1,712	3,082

"Big lime" at 3,082 feet.
Bottom of well in "Big lime" at 3,186 feet.

As the record shows, the drill stopped far short of the Clinton, and while it was a failure so far as its object was concerned, it performed a useful service to geology by providing additional information on the deeper formations in this part of Ohio. The point of most interest is the great thickness of the Ohio shales, a fact already referred to in this report and in previous ones.

Only one well in the county has reached the Clinton sand, and that was on land of T. J. Chappalear in the southwestern corner of Union Township. The well was located on Bloody Run about three-fourths of a mile above the old Blackburn P.O., near the northern margin of Section 32. The altitude of the well head was 750 feet, and was not far from the horizon of the Cambridge limestone. Both this and the Ames limestone are well shown in the vicinity. Mr. J. P. Fishel, the contractor, has furnished the following data from the driller's record:

	Thickness. Feet.	To bottom of formation. Feet.
Berea sand	20	1,170
Bedford and Ohio shales	1,530	2,700
"Big lime"	900	3,600
Clinton sand	9	3,944

Bottom of well in red rock at 3,947 feet.

Not a smell of oil or gas was found. The "Big lime" yielded only about a bailer of water an hour, and it was not necessary to case in it. The geological fact of most interest is the great distance between the "Big lime" and the Clinton, 335 feet. At Bremen this interval measures only 103 feet, but at New Straitsville it has increased to 171.

HOCKING COUNTY.

The west central part of this county contains an important part of the great Sugar Grove gas field, but that does not fall within the scope of this discussion. On the eastern side of the county a number of Clinton wells have been drilled and these will now be considered:

Falls Township.—The county seat, Logan, is in this township. Naturally its citizens viewed with admiration the discovery in large quantity of gaseous fuel at Lancaster and vicinity, and as early as 1890 drilled a test well. This was on North Walnut Street, the elevation of the well head having been about 748 feet. For the following log the survey is indebted to Mr. A. Magoon:

	Thickness. Feet.	To bottom of formation. Feet.
Drift	40	40
Logan sandstone	170	210
Cuyahoga shales	439	649
Sunbury (Berea) shales	34	683
Berea sand	45	728
Bedford shales	85	813
Ohio shales	902	1,715
"Big limes" Devonian ...... 75 feet Monroe .... 300 feet Niagara and Clinton .... 340 feet	715	2,430
Shales	197	2,627
Clinton sand	18	2,645

Total depth 2,694 feet.

To an unusual degree this gives the formations and their thicknesses, and may be taken as representative for that section of the State. In one or two places the writer has made slight changes in the names, making them conform with the nomenclature in present usage. The shales between the "Big lime" and Clinton sand are left without a name, though Mr. Magoon called them Niagara. According to the writer's interpretation the base of the "Big lime" is represented by the Clinton limestone, and the shales lying beneath it could not therefore be the Niagara.

Not satisfied with this failure, another well was drilled to the Clinton, the location being on the western edge of the town, but a show of gas was the only reward. Some years ago a well was drilled at Enterprise in the northwestern corner of the township. The Clinton sand was found and made a showing of oil, but the well was abandoned. Later a hole was drilled on the Hensel farm, southeast quarter of Section 27, where the following record was made:

	Thickness. Feet.	To bottom of formation. Feet.
Berea sand	40	680
Bedford and Ohio shales	978	1,658
"Big lime"	737	2,395
Clinton sand	22	2,584

A flow of gas was secured at 512 feet in sand in the "Big lime." The Clinton was much broken and without anything in commercial quantities, and the well was abandoned.* Two holes have been drilled in the southwestern corner of the township, one on Section 30 and the other on Section 31: both were failures.

Marion Township.—This is the northernmost township of the county. It lies south of Rush Creek of Fairfield which contains important deposits of both oil and gas, and of course has been well tested. Along the western edge a number of gas wells were secured some years ago, but most of them have been abandoned.

Quite recently a test was made on the farm of H. R. Bending, northeast quarter of Section 25. For the following record of this the Survey is indebted to J. P. Bebout, county surveyor; elevation of well head, 983 feet.

	Thickness. Feet.	To bottom of formation. Feet.
Berea sand	35	950
Casing 6⅝ inch, 982 feet.		
Bedford and Ohio shales	990	1,940
"Big lime" at 1,940 feet.		
Clinton sand	26	2,941
Green shales	30	2,971
Limestone	20	2,991
Red shales	8	2,999
Limestone	0⅔	2,999⅔
Blue shales	13	3,012⅔

After shooting, the well caved badly and has not been cleaned, though it made a little oil. The casing and a string of tools rest in it. Other tests of the Clinton sand have been made as follows: northeast quarter of Section 4; southeast quarter of Sections 9 and 10; along the southern edge of 11, and northeast quarter of Section 21. None of these found the sand with anything better than a showing of oil or gas.

Falls Gore Township.—Within the past year or two a number of tests have been made in this township. One on Section 30 yielded some oil, and, encouraged by this, a well was drilled in the spring of 1910 on the Terrell farm nearby, where the following succession was found:

	Thickness. Feet.	To bottom of formation. Feet.
Big Injun sand	190	290
Berea sand at 726 feet.		
"Big lime"	720	2,560
Clinton sand	22	2,801
Bottom of well 2,838 feet.		

After shooting, this well began flowing between 10 and 20 barrels of oil a day.

About the time that the above wells were being sunk, the drill was busy near Gore on the eastern side of the township. In the autumn of 1909 one was completed on the Lemon farm in the southwestern quarter of Section 25, and the Clinton sand, 26 feet thick, was found at 2,987½ feet. After shooting with 40 quarts of nitroglycerine, the well caved badly and has not been cleaned. It flowed as high as 63 barrels of oil a day, and in July, 1910, was pumping about 25 barrels.

Early in September, 1910, a well was completed on the Williams farm, Section 33, about a mile west of Gore, and 26 feet of Clinton sand found, the top at 2,866. The well has not been connected with the pipe line and its capacity cannot be accurately stated, but it will not be far from 25 barrels.

Green Township.—In 1888, when the excitement about natural gas was high, a deep well was drilled at Haydenville with the hope of securing that fuel for use in the clay industries. The first well found the Berea sand at 788 feet which yielded 100,000 cubic feet of gas per 24 hours. A second well was soon begun, but found that sand without fuel of any kind, and it was decided to continue to the Clinton which was then giving such fine results farther north. A record of this well provided by Mr. J. W. Jones, of Logan, follows. Its elevation above sea level was very nearly 710 feet.

	Thickness. Feet.	To bottom of formation. Feet.
Maxville limestone	8	39
Sandstones, shales and conglomerate	306	345
Large flow of salt water at 250 feet.		
Cuyahoga and Sunbury shales	443	788
Berea sand	44	832
Bedford and Ohio shales	1,108	1,940
"Big lime"	800	2,740
Shales	145	2,885
Red and green shales	33	2,918
Clinton sand	12	2,930

The well did not show either oil or gas.

Sandstone in the "Big Lime."—In Sections 21 and 22 and probably others of Laurel Township a layer of sandstone, with a maximum reported thickness of 40 feet, is found in the "Big lime," and occasionally yields oil and gas. The oil is dark and heavy and is rarely in commercial quantities, but the gas wells are occasionally valuable. The same general condition holds in Falls and Falls Gore townships. This sand is found also in Berne Township of Fairfield County, but has not been reported in the Bremen field.

ATHENS COUNTY.

So far as the writer knows only one Clinton well has been drilled in this county. This was at Buchtel in York Township and was sunk by the Columbus Hocking Coal & Iron Company. No further information is at hand beyond the fact the well yielded neither oil nor gas in commercial quantities.

VINTON COUNTY.

A large amount of exploration has been done in the Clinton sand of this county for oil or gas, but primarily the former. The measure of success has been small for both. For the benefit of seekers after these fuels the tests and their results will be reviewed briefly here.

Jackson Township.—This is the only township in the county that has yielded Clinton oil in commercial quantities. As already stated, the first well was completed in August, 1899. By September, 1902, five oil wells, one gas well and three dry holes had been drilled. Nearly all of these lie in Sections 3 and 4, along the Vinton-Hocking line. These wells are now the property of the Southern Ohio Oil Company. Two new wells were drilled near these in 1909 and small producers secured. These belong to the Locust Grove Ridge Oil & Gas Company. Dry holes nearly surround the pool and important extensions need not be expected. In all about 12 wells have been sunk to the Clinton in this township.

Early wells ranged in production from 10 to 70 barrels per day, later ones being smaller. In the late spring of 1902 the four producing wells then completed were yielding 125 barrels a day. By the following September the production from five wells had dropped to 109 barrels and in July, 1910, to 12 barrels or less, one well alone producing nearly one-half of this. At the same time the two wells drilled in 1909 were making 7 barrels per day. The gas pressure is strong with the result that an occasional flow of oil still takes place. The oil has a density of 47½° Beaume and a green color, but when viewed in small quantity with transmitted light its color is amber.[1] At first the oil was pumped to Orland on the Hocking Valley Railroad and then shipped in tank cars. Later the line was extended to Joy and this method of shipping is still followed.

The producing sand is quite spotted, and this increases the hazard of drilling, but it is soft, and consequently the wells seldom require shooting. Commonly the "pay" has the color of brown sugar, but sometimes it changes to red-brown. Little or no water exists in the sand, and when the pool was visited in July, 1910, no well was reported making as much as one barrel of water a day, and the largest oil well no water at all.

Following is a skeleton record of Clinton Well No. 1, whose altitude above sea-level is approximately 875 feet.

	Thickness. Feet.	To bottom of formation. Feet.
Berea sand	45	750
"Big lime"	700	2,270
Heavy flow of brine at 2,010 feet.		
Clinton sand	15	2,443
Bottom of well 2,449.		

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[1] For analysis of oil see p. 17.

Richland Township.—This lies south of Jackson, and has at least six wells to the Clinton. The first of these was drilled early, probably in 1898, but may not have reached the sand. It was located on the east side of Section 4, but gave neither oil nor gas. A little later a well was drilled on land of William Poland, in Section 28. The Clinton was found at approximately 2,340 feet, and gave a heavy flow of gas, which is still used. Encouraged by this result, two additional wells have been sunk on this section, but were failures.

A test has been made on the Wyatt land, near the center of Section 10, but was a failure. The Clinton was reported about 11 feet thick, with a little gas in the top and near the bottom. About 1902 or 1903 a well was drilled on the John Bethel land in the northern part of Section 21; the Clinton, 14 feet thick, was found at 2,377 feet, but was without oil or gas. About the same time a well was drilled on the Radcliffe farm, in the southeastern quarter of Section 6, in the northwestern corner of the township. The "Big lime" was struck at 1,264 feet and the bottom at 1,855. Fifty feet of Clinton sand were found, the top at 2,080. Neither oil nor gas was present in the sand, but a little dark, heavy oil was found in the "Big lime," which was bailed out, but was not renewed.

Swan Township.—This contains a number of deep wells. The first was located on the Cradlebaugh land, about one mile south of Orland, and was drilled in 1901. The Clinton sand was found at a depth of about 2,900 feet, and contained gas. The rock pressure was at least 800 pounds to the square inch, but the open flow was disappointing, being only about 400,000 cubic feet per day. In the following year a well was drilled on the Wadsworth farm, about one-half mile north of the last one. The Clinton sand, in good quality, was found at a depth of 2,811 feet, but was entirely dry.

Near the center of Section 2, on the E. H. Waller farm, the Clinton gave nothing better than a show of gas. On land of George Schurtz, near the middle of Section 15, a little more gas was found, but not enough to warrant tubing. A well on the northwest quarter of Section 14 was dry, and the same is true of one on the northeast quarter of Section 29. No data are at hand with reference to the depth of these, the nature or thickness of the sand. Several wells have been drilled for gas with favorable results near the middle of the western edge of the township.

Clinton Township.—Only one Clinton well is reported in this township. This is on the farm of I. N. Bay, and was drilled in 1910. The Clinton is reported as having been found at between 2,600 and 2,700 feet, but was dry.

Vinton Township.—In 1909 a well was completed on land of Vinton Cattrell, in Section 13, the well head being about 613 feet above sea level. The "Big lime", 900 feet thick, was struck at 2,160 feet, and ten feet of Clinton sand at 3,210 feet. A depth of 3,268 feet was reached, but neither oil nor gas was secured. For these brief facts the Survey is indebted to Mr. E. F. Clagett, of Columbus.

GALLIA COUNTY.

About the year 1898 a well was drilled to a depth approximating 3,200 feet near the village Vinton. No details concerning this have been received, but the Clinton sand was not found, and, of course, neither oil nor gas was secured.

JACKSON COUNTY.

Four wells to the Clinton sand have been drilled on Section 20 of Washington Township, two on land of the Buckeye Coal Company and two on the farm of Richard Wills. No. 2 on the Buckeye Coal Company tract was a gas well having rock pressure of 980 pounds and an open flow of 4,000,000 cubic feet per day. No. 1 on the Wills farm started at 500,000 cubic feet. The remaining two wells were dry. Following is a record of Buckeye No. 2:

		Thickness. Feet.	To bottom of formation. Feet.
Conductor		16	16
Casing 10 inch, 74 feet			
Berea sand		20	660
Casing 8¼ inch. 680 feet.			
Bedford and Ohio shales		794	1,454
"Big lime"		596	2,050
Shales from 1,750 to 1,760 feet.			
Casing 5$\frac{3}{16}$ inch, 1,946 feet.			
Shales: chocolate	140 feet	205	2,255
white	40 feet		
brown	15 feet		
white	10 feet		
Clinton sand		8	2,263
Shales: white	44 feet	52	2,315
red	8 feet		

Bottom of well at 2,315 feet.

No. 1 on the Wills farm showed only four feet of sand, and No. 2 none at all. These figures can hardly be rated encouraging to the prospector. As previously reported, the "Big lime" continued to contract, while the underlying shales thicken.

About the year 1903-4 a test was made on the Gerkins farm, about three miles northwest of Oak Hill, and a depth of about 2,700 feet reached, but no Clinton sand was found.

PIKE COUNTY.

A few tests have been made for oil or gas in the Clinton sand in this county. Thus far neither has been found, and there is no reason to expect better results. One of the tests was at Waverly, and because of its depth and the unusually complete record a full report of it is given. First acknowledgment is made to Mr. Peru Hutt, who not only kept a detailed log of the well, but also 68 samples of the drillings, representing every type of rock penetrated. He generously permitted the writer to examine these, and furnished also an interesting account of the trials and tribulations of drilling a well more than 3,000 feet deep. The latter will be reviewed, and then the well record given.

In the spring of 1908 a group of men from the East started drilling, the location being in a hollow a little north of west of the Detroit, Toledo & Ironton Railroad station at Waverly. All went well until at a depth approximating 780 feet, when a heavy flow of water was encountered. Casing was inserted, and drilling resumed, when another flow was found. A longer string of casing replaced the first one, and again the drilling started. Soon another heavy flow was found, and the casing had to be withdrawn two or three times more before the lower limit of water was passed. So abundant was the supply that it flowed from the top of the well, and when it was cased off, flowed outside to the surface, and now from the abandoned hole. It has a strong odor of hydrogen sulphide. The water came from the "Big lime," as anyone who has read the preceding pages might conclude.

These troubles delayed the drill, and progress was slow. When a depth of 1,428 feet was reached the company was without the necessary funds to continue, and citizens of the town, desiring to see a first-rate test made, organized the Waverly Oil & Gas Company. When drilling was again resumed, January 4, 1909, it was found that the hole had filled to a depth of about 400 feet with shales or clay, the result of a cave from below the "Big lime." The hole was soon cleaned, and good progress made to a depth of 1,960 feet, when the Trenton limestone was struck, which checked, but did not stop, the advance. At 2,250 the rock became harder, and this variety continued until the bottom of the formation was reached, at a depth of 2,810 feet. A trace of oil was found at a depth of 1,960 feet. While this great formation was being penetrated, the caving of the overlying shales became so troublesome that the casing had to be drawn again and a string inserted that reached below the base of the cave. By that time the hole had filled more than 1,000 feet with the shales or clay, and after removing 700 feet the cable broke and the drill buried itself in the shales remaining in the hole. Fishing tools were gotten, and after working four days the drill was recovered.

A new cable was ordered at once and received on the following day. Drilling was resumed three days later, the tools advancing about one foot an hour. On March 13 the bailer broke, leaving that necessary tool at the bottom, about 2,725 feet below the surface. This was fished out without great trouble and the base of the Trenton limestone reached. On entering the sandstone that underlies that formation, water was again encountered; at first this was not abundant, but as the drill descended the volume increased, and at a depth of about 2,900 feet rose to within 400 feet of the surface. At about 2,960 feet the bailer was again lost and for nine days rested on the bottom of the well.

Water in the hole made drilling extremely slow with a hemp cable, and a wire one 3,500 feet in length and seven-eights of an inch in diameter was purchased. April 20, 1909, at a depth of 3,188 feet the new cable broke and the tools with about 3,000 feet of the wire were in the well. These were recovered the next day, but ere long the cable broke again. Not to allow one part of the outfit to monopolize attention, the walking beam gave way on June 7, but was replaced with a timber from the forest primeval, and work resumed a week later. The cable stranded the next day, but was spliced and drilling resumed without notable interruption until June 30 when the bailer with 400 feet of the sand line were lost in the well. Again it was fished out and the drill started.

June 18 a new 3,500 foot wire cable was purchased and put to work on the 25th. Five days later the bit was lost in the well at a depth of 3,250 feet and the bailer on top of it. While fishing for the tools on July 11, the new cable severed, leaving the fishing tools and 1,700 feet of cable in the hole. The board of directors met July 14, 1909, received a report from their manager and suspended operations. Later the casing was drawn and all that now remains to show for the $12,000 is an artesian well with a pungent odor and a derrick that will soon yield to a stiff wind. The troubles recorded were not the only ones, numerous as they were, but sufficient to show the difficulties that may accompany drilling very deep wells.

Record.—Waverly Oil & Gas Company's well at Waverly, Ohio. Began drilling in the spring of 1908; suspended operations July 14, 1909. Elevation of well head 575 feet above ocean level.

This record with samples of drillings was kept by Mr. Peru Hutt. The figures are his, but the formation names were supplied by the writer after an examination of the samples. Mr. Hutt's interpretation of the record is different from that which follows:

Number of sample.		Thickness. Feet.	To bottom of formation. Feet.
1	Mantle rock	35	35
2	Black shale	300	335
3	Gray shale	150	485
4–5	Fawn colored limestone	140	625
	Sulphur water at 510 feet.		
6	Gray sandstone	50	675
7	Gray limestone	25	700
8	Buff limestone	50	750
9	Dark gray limestone	25	775
	Salt water and gas at 780 feet.		
10	Dark gray limestone	15	790
11	Yellow limestone with shale	45	835
12	Black, yellow and white limestone	60	895
13	Brown mottled limestone	80	975
14	Chocolate shales	40	1,015
15	Green shales	50	1,065
16	Light brown and green shales	303	1,368
17	Gray shales	532	1,900
18	Dark and light shale with trace of oil	10	1,910
19	Dark shale	50	1,960
20–22	Dark and gray limestone	170	2,130
23	Gray limestone	60	2,190
24	Buff limestone	210	2,400
25	Dark limestone	20	2,420
26–27	Buff limestone	20	2,440
28	Darker buff limestone	45	2,485
29–32	Light and dark limestone	255	2,740
33	Light limestone and dark shales	8	2,748
34	White sandstone	82	2,830
35	White sandstone and dark green shales		
36	Dark green shales and white sandstone		
37	Gray sand		
38	Light yellow sand		
39	Gray sand (show of oil and gas from 34–39)		
40	Gray sand and dark shale	75	2,905
41–43	Dark shales, fossiliferous	50	2,955
44–47	Buff limestone and dark shales	65	3,020
48	Dark green shales, soft	10	3,030
49–68	Buff limestone and dark shales	285	3,315
	Gas at 3,270 and 3,322.		

In measuring an error of about 3 per cent was made. The depth of the well was 3,220 feet.

Simplifying this record we have the following:

		Thickness. Feet.	To bottom of formation. Feet.
1	Mantle rock	35	35
2–3	Ohio shales	450	485
4–13	"Big lime"	490	975
14–19	Silurian and Ordovician shales	985	1,960
20–33	Trenton limestone	808	2,768
34–40	St. Peter's sandstone and shales	157	2,925
41–43	Dark shales, fossiliferous, unclassified	50	2,975
44–68	Buff limestone and dark shales (Lower Magnesian?)	360	3,335

At a depth of 140 feet in the "Big lime," a bed of white sandstone, reported 50 feet thick, was found. This fact, with the drillings above and below responding but slightly to cold acid, misled those interested in the well and the entire series was called sandstone or sandstone and shales. When these drillings, with the exception of the sand, were treated with hot acid, free effervescence took place, showing that the rocks are dolomitic limestone. The lower 80 feet resemble the Clinton limestone along its outcrop and are so classified; in fact the 60 feet above this may also be placed with the Clinton, but the evidence was not conclusive. The writer was unable to determine how much of the remaining parts belonged each to the Niagara, Monroe and Devonian limestones. Probably the sandstone forms part of the Monroe ("Lower Helderberg").

The shales between the "Big lime" and the Trenton represent the Clinton, Medina (if that formation is present in southern Ohio) and the Cincinnati and Utica of the older Ohio reports. As the section shows, the Clinton sandstone was not found, substantiating the statement already made that it does not extend as far west as the Scioto River.

The Trenton limestone is represented by 808 feet, a somewhat greater thickness than has heretofore been reported for southern Ohio. It contains little shale, has a buff, gray or dark color and responds freely to cold acid, showing it is not dolomitic. In the latter respect it differs from the great repository of oil in northwestern Ohio.[1] The upper 300 feet contained some shale and drilled fairly easily, but below that was solid limestone, except eight feet at the base.

Below the Trenton is a formation whose name is not well known in Ohio geology. In this record it consists of 82 feet of light colored sand and a subordinate quantity of shale, overlying 75 feet of gray sand with a larger proportion of shales. A similar formation underlies the Trenton in Illinois and other western states, and has been named the St. Peter's sandstone. This name is applied to the rocks in question in Ohio.

The St. Peter's sandstone is underlaid with 50 feet of dark shales that stuck to the bit and hence were hard to drill. Specimens brought up by the bailer show numerous fossils, but the fragments are so small that the forms are hard to identify. Whether these shales should be classed with the overlying formation or the one beneath, the writer is unable to say.

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[1] Orton, Edward. *Geol. Surv. of Ohio*, Vol. VI, p. 103.

The lowest rocks penetrated in this well, representing 360 feet, consist of buff limestone interbedded with dark shales, the latter resembling the 50 feet reviewed in the last paragraph. The proportion of shale to limestone varies. In No. 58 the two appear to be nearly equal; in 59 the shale is less abundant; in 67 it comprises more than 50 per cent.; in 68 the drillings resemble pepper and salt; in other bottles the limestone is most abundant, and in some there is just enough shale to be easily visible. The limestone responds slowly when treated with cold acid, but acts freely when the acid is hot, indicating its magnesian or dolomitic character.

Below the St. Peter's sandstone in Illinois and neighboring states lies the Lower Magnesian limestone. The rocks in the basal portion of the well at Waverly resemble those in composition and position, and are probably their eastern extension.

LAWRENCE COUNTY.

This, the southernmost county in the state, has been tested to or below the horizon of the Clinton sand at two or more places.

In 1885 a well was begun at Ironton for natural gas. Not finding the fuel in the Berea sand, which was struck at 1,010, it was decided to push on to the Trenton, which was then attracting so much attention in Northwestern Ohio. Work was continued somewhat irregularly until the middle of 1887, when a depth of 3,600 feet was reached. Dr. Orton was of the opinion that the Trenton was probably struck at 3,440 feet. No Clinton sand was reported, and it is a fair conclusion none was found. Following is Dr. Orton's interpretation of the record:

	Thickness. Feet.	To bottom of formation. Feet.
Coal measures	282	282
Logan and Cuyahoga groups	728	1,010
Berea sand	47	1,057
Bedford and Ohio shales	770	1,827
"Big lime"	584	2,411
Silurian and Ordovician shales	1,029	3,440

Trenton limestone at 3,440 feet.
Bottom of well at 3,600 feet.

It should be stated that Dr. Orton was not sure that the Trenton was reached at 3,440 feet, but at any rate that figure is not far from the true position. The well head he places at a "little less than 500 feet above tide."

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[1] Orton, Edward. *Geol. Surv. of Ohio*, Vol. VI, p. 304.

Not believing the result of this test condemnatory for the county, another well was drilled in 1906, the location being at Mt. Vernon, near the middle of Decatur Township. Following is the record:

	Thickness. Feet.	To bottom of formation. Feet.
Berea sand	25	1,120
Bedford and Ohio shales	690	1,810
"Big lime"	620	2,430
Shales of various colors	289	2,719
Red rock (shales)	11	2,730

This well, too, found no Clinton sand. Probably the red rock struck at 2,719 feet lies just below the desired formation. These tests are all the more discouraging because in neither was the Clinton sand present, leaving the prospect anything but flattering for the county.

CHAPTER III.

THE SEARCH FOR THE CLINTON SAND NORTH OF THE BREMEN FIELD.

The extension of the gas field into Knox County greatly encouraged drilling in Northern Ohio, with the result that tests have been made to the shore of Lake Erie. These have shown the Clinton sand somewhat spotted in Richland County, usually if not always absent in Huron, thin and uncertain in Lorain and Cuyahoga. Apparently the sand thickens to the east and southeast, but the tests have been few, owing to the depth of the formation. While both oil and gas have occasionally been found, the yield has not been in proportion to the great expense.

LICKING COUNTY.

While this county has long been a heavy producer of natural gas from the Clinton sand, it has not yielded oil in commercial quantities, with the exception of an occasional well in the gas belt.

In September, 1910, a well was completed on the Deeds farm, about two miles west of Union Station in Union Township, and 10 feet of sand found, the top at 2,218 feet. After shooting, the hole filled 1,800 feet with oil, and when tubed began flowing at the rate of 30 barrels per day. About a half-mile northeast is a gas well, and another the same interval due west. Two dry holes have been found, one three-quarters of a mile southwest and the other a mile southeast of the oil well.

In October, 1910, a well was completed on the Ashcroft farm, in the southeast corner of Fallsbury Township. The Clinton sand was struck at 2,875 feet, and was 40 feet thick. It began producing oil but the rate has not been determined at date of writing. For the following record of this well the Survey is indebted to Mr. G. C. Scott, of Columbus:

	Thicknes. Feet.	To bottom of formation. Feet.
Drive pipe	58	58
Berea sand	20	632
Casing 6⅝ inch, 650 feet.		
Bedford and Ohio shales	1,168	1,800
"Big lime"	912	2,712
First water at 2,400 feet.		
Second water at 2,440 feet.		
"Big water" at 2,475 feet.		
Casing $5\frac{3}{16}$ inch, 2,612 feet.		
Shales	163	2,851
Clinton sand	40	2,915

Break in sand from 2,892 to 2,894 feet.
Depth of well 2,927 feet.

KNOX COUNTY.

While this is a large producer of gas from the Clinton, its yield of oil from that formation is small. At the present time (August, 1910) the producing wells number about a baker's dozen and are scattered over four townships in the eastern and northern parts of the county. The results have not been at all in harmony with the labor, and in fact the fuel secured has been simply enough to lead the operator on with the hope that a large deposit might be near.

Jackson Township.—This contains the best known pool of oil in the county, but it is of doubtful value. In August, 1904, a well was completed on the McKee farm in Section 14. The Clinton sand was struck at 2,771 feet, and began flowing oil at about 35 barrels per day. A second well was sunk at once, and a very small producer secured. The third well was drilled a few hundred yards farther west, on the Hall farm, and a 10-barrel producer secured. The fourth well of the field was drilled on the same section, but a little bit farther south, on land of John Wolf, the result being similar to that on the Hall farm. One more producing well was secured in this field. It was located between the Wolf and McKee wells, and started at about 15 barrels per day. An effort to extend the pool northward met with failure. A dry hole was drilled to the north and just across the road from the McKee well, and a like result followed on the Blymer farm about two miles to the northwest. Here, however, a little oil and gas were secured. The latter was used a short time for a boiler, and then the well was abandoned. The last failure recorded was on the Kerr farm, in the southeastern quarter of Section 4.

Four of the five producing wells secured in this township are still producing. The McKee, which all along has been the best in the field, now pumps about 8 barrels in 10 hours, while the other wells are smaller and not pumped daily. Each makes about one and one-half barrels of water per day, indicating that this is in the sand, for it is hardly possible that the casing in all would leak at the same rate.

Oil from the McKee well has a dark color, and at a temperature of 68° F. a density of 35° Beaume.[1] The oil is shipped by pipe line to Cooperdale, on the C. A. & C. R. R.[2]

Finally there is added a record of the McKee well, furnished by the driller, Mr. Irving Forbing, of Mt. Vernon:

	Thickness. Feet.	To bottom of formation. Feet.
Drive pipe, 8 inch	30	30
Berea sand	10	680
Casing 6½ inch, 680 feet.		
"Big lime"	863	2,623
Clinton { sand 35 feet shale 4 feet sand 10 feet }	49	2,820

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[1] For analysis of this oil see p. 17.

[2] This pool is commonly known as the Bladensburg.

The division of the oil rock into two parts by a few feet of shales, while uncommon, is occasionally reported from different parts of the State.

Butler Township.—Only one test to the Clinton sand is reported from this township. This was on the Beal farm in Section 4 and was a failure.

Union Township.—Two wells are reported to the Clinton. About the year 1907 a test was made on land of David Colopy in Section 22; it gave a little gas, but not enough for commercial purposes and was abandoned. The other well is just west of Danville and yields gas.

Jefferson Township.—This lies north of Union and comprises the northeastern corner of the county. Nine wells to the Clinton sand have been drilled, the result being four small oil wells and five failures. On land of Henry Black in the extreme southeastern corner of the township, two small oil wells have been secured. The first, which was drilled about 1907, began flowing 5 barrels of oil per day, but a little later an accident occurred and the well was ruined. About 1908 the second well was completed and is reported to have begun producing approximately 17 barrels of oil daily. It is now pumped every other day.

About one mile west of the hamlet, Greer, three wells have been sunk to the Clinton, the result being two oil wells and one dry hole. The well on the Tisserand farm was drilled about 1904 and is still producing. The other successful well is reported to have begun flowing 25 barrels per day and still yields some oil. South of these wells and near the middle of Section 8 a test has been made, but the result was failure. Two wells are reported from the southern half of Section 14; one yielded some gas, but the other was a complete failure.

Howard Township.—This lies north of the eastern terminus of the great gas field and has been tested to the Clinton in at least 4 places. The only well that made a show of success was drilled about one mile south of Howard on the Lindza Horn farm, perhaps in 1908. It started producing 10 barrels of oil per day and now yields about half that quantity. About two miles west of this place the result was failure and the same is true of two wells near the village, Howard.

Brown Township.—This lies north of Howard and has been twice tested, both being in the southeastern corner of the township. About 5 years ago a well was drilled on land of Channing Rice in the valley of Jellow Creek, but was dry. In 1909 a test was made on the farm of Edward Grant, approximately a mile southwest of the Rice well, and like the latter was a failure.

Monroe Township.—This lies northeast of Mt. Vernon and has been tested to the Clinton in at least three places. One of these was near the middle of the eastern border of the township and two along the western. All were dry.

Pike Township.—Only three Clinton wells are reported from this township. About 1906 a gas well was secured on land of Robert Shira in the southwestern quarter of the township. The rock pressure was reported at 1,250 pounds per square inch. In 1909 a test was made about a mile and one-half to the northwest on land of James Phillips, and a small oil well secured. It started at 5 barrels per day and is still producing. A well drilled on the farm of Thomas Simmons in the south central part of the township was a failure.

Berlin Township.—Three small oil wells were secured in 1906 and 1909 in the Clinton on land of Joseph Love, near the eastern border of the township. These started at from 5 to 15 barrels per day and are still producing. A half mile to the northwest another test was made with the hope of extending the pool, but without success. Failure also resulted from two wells, one drilled about a mile northeast of Fredericktown and the other about twice that distance southeast of the village.

Other Townships in Knox County.—The part lying south and west of the county seat comprises an important part of the great gas field, but that constitutes no part of this bulletin and so will not be discussed. The territory near or along the western border of the county has been amply tested, but without favorable results.

RICHLAND COUNTY.

One small pool of oil has been found in the Clinton in the southeastern corner of the county. While the production from this has been small and the balance is probably on the wrong side of the sheet, the scientific problems presented are of more than ordinary interest. Considerable drilling has been done farther north, but the results have been unfavorable.

Worthington Township.—This is the extreme southeastern corner of the county and contains the one pool of oil already referred to. For the history of this, the Survey is indebted to Judge F. O. Levering, of Mt. Vernon.

In June, 1905, a well was completed by the Butler Oil & Gas Co., on land of Mary McClellen in the southwest quarter of Section 28. The Clinton sand, 6 feet thick, was struck at a depth of 2,518 feet and gave a heavy flow of gas. The rock pressure reached the astonishing figure of 1,260 pounds to the square inch and the open flow started at 4,700,000 cubic feet per day. August 1, 1910, it was yielding 150,000 cubic feet against a line pressure of 200 pounds to the square inch.

The next test was in the northwest quarter of Section 33, but no Clinton sand was found and of course the well was a failure. The third well in the field was on the Mengert heirs farm in the northwest quarter of Section 33. It was completed in December, 1905, and its record is unique among the many thousand wells of Ohio. No tankage had been provided and so the flow during the first day was not determined, but it was estimated at 200 barrels and the *oil was water white.* The first day the oil could be measured, the flow was 132 barrels. By the close of January, 1906, the production had dropped to 87 barrels per day, and about November 1, 1906, the yield had become so small that it was abandoned as an oil well and used for gas, of which it had been prolific from the start.

The production all told was about 1,600 barrels of oil, and was all of the water white variety. It commanded a price 10 cents in advance of the regular Pennsylvania grade. People residing nearby used the oil in lamps and lanterns, for which it seemed well adapted, but the owners, fearing explosions, stopped this practice. No accident resulted from its use. The well is still used for gas and its owners state that it will produce small quantities of the white oil now if allowed to flow a few days.

Following are a few facts from the driller's record:

	Thickness. Feet.	To bottom of formation. Feet.
"Big lime"	890	2,430
Clinton sand	6⅓	2,516⅓

This shows that the interval between the "Big lime" and the oil and gas rock is only 80 feet, which is much less than usual in other fields. The "Big lime" is normal and the short interval below it may give the Clinton sand a low dome shape. The sand had a gray color and was quite soft. No water at all was produced while the well was flowing oil, and very little after it began to be used for gas. It was shot with 20 quarts of nitroglycerine.

Greatly encouraged by this well the company began three additional ones in the spring of 1906. In the meantime the Standard Oil Company had entered the field and started three strings of tools at work. For a 40-acre lease this company is reported to have paid $7,700 on which it drilled one well that was a total failure; and $3,500 for a 67-acre lease, on which it secured two oil wells, one starting at about 5 barrels and the other at approximately 15. Toward the close of 1907 these were abandoned as oil wells, but one was used for gas about a year longer.

Of the three wells started by the Butler Oil & Gas Company, referred to in the beginning of the preceding paragraph, two were dry, while the third (drilled between two dry holes), completed in March, 1906, started flowing 40 barrels of water white oil. In the following September the well was shot with 30 quarts for the first time, the production of both oil and gas being notably increased. Later the flow of oil having again become small, the well was connected with gas mains and is still used in that way. In April, 1906, the company went into the hands of a receiver and sold out the following June to Waight & Levering, who are the present holders of the property. Later these men drilled a dry hole in the southwest quarter of Section 28, one on the northeast quarter of Section 32 and another on the northwest quarter of the same section. The last well drilled in the field was located on the southeast quarter of Section 29. This is about a half mile from the nearest gas well, but the rock pressure was only 600 pounds while the open flow started at 5,000,000 cubic feet per 24 hours.

When the excitement was at its highest in the spring of 1906, Smith, Kerr & Neely entered the field and secured a small oil well. This flowed at first, but later was pumped, and was abandoned in about two years. Still believing in the territory, the Fredericktown Oil & Gas Company drilled three holes in the northwest quarter of Section 28, securing two gas wells, one of which was very small and a dry hole. Seventeen wells in all were drilled in the Butler field. Eight of these were total failures, involving an expense aside from leases of at least $30,000.

All oil wells in this field produced the water white variety that resembles kerosene. As has already been shown, these were short lived, produced much gas and always or nearly so changed to gas wells. The rock pressure in the field was not uniform, but ranged from approximately 600 to 1,260 pounds. Not a well was producing oil in 1910.

Finally there is given a record for a well, the first drilled in the field:

	Thickness. Feet.	To bottom of formation. Feet.
Drive pipe	56	56
6⅝ inch casing, 555 feet.		
Berea sand at 600 feet.		
"Big lime"	881	2,391
Clinton sand	6	2,524
Total depth 2,559 feet.		

The sand is thin, and, according to Judge Levering, was absent wherever oil or gas was wanting. Formations to the base of the "Big lime" were regular, but those below were not so. Wherever oil was found the interval between the sand and the limestones was reported less, due to a rise in the oil rock. According to this the Clinton is uneven, forming very low domes and shallow basins. In the higher of these, oil was found and in the lower gas.

Outside of Worthington Township, quite a number of Clinton wells have been drilled in Richland County, but the results have been far from satisfactory. In Jefferson Township, along the southern edge of the county, at least half a dozen tests have been made, but the only reward has been a small gas well or two. Four wells have been sunk in the southwestern corner of Monroe Township, three of which were failures, while the fourth yielded gas.

Madison Township contains the flourishing manufacturing city of Mansfield, and, as might be expected, the rocks have been tested for mineral fuels. As early as 1886, a well in search of gas was drilled, reaching a depth of 2,005 feet, but was a failure.[1] Twenty years later a test was made on land of A. Burnison, about two miles southwest of Mansfield. The well record, provided by Joseph Schrier, is as follows:

	Thickness. Feet.	To bottom of formation. Feet.
Drive pipe	125	125
Berea sandstone	40	600
"Big lime"	915	2,215
Flood of salt water at 1,990 feet.		
Shales	54	2,269
Medina shales (red rock) at 2,270 feet.		
Bottom of well (in red rock) 2,435 feet.		

As the record discloses, the much sought after Clinton sand is wanting and it is doubtful if it exists as a continuous or well-marked formation farther west than Mansfield. Patches of it, however, may from time to time be expected. The sand is very uncertain also in the southern half of the county and according to Judge Levering, of Mt. Vernon, the absence of oil or gas is characterized by the absence of the sand also.

This well was not without reward. At a depth of 1,910 feet or 610 feet in the "Big lime" a heavy flow of gas was struck. The closed or rock pressure is reported as having been 580 pounds and the open flow 1,200,000 cubic feet per day. From that time the drill has been at work irregularly in the neighborhood, and in all about 16 wells have been drilled to the "lime," only two or three of which were failures. The wells varied considerably in production, the largest having started at 3,500,000 cubic feet per day. The producing rock is said to be a limestone and not a sandstone in the "lime." Its position is usually about 640 feet in that formation, but figures of 390 and 500 are reported. The gas has a pungent odor and is not suitable for domestic purposes, but does very well for boilers. In drilling, care must be exercised not to strike the "big water" lying below the gas rock.

Along the P., Ft. W. & C. R. R., about two miles southeast of Mansfield, a Clinton well has been drilled, but no information concerning it has been secured beyond the fact that it was dry. A well is now drilling about three miles east and a little north of the one just mentioned. In Weller Township, northeast of Mansfield, two tests have been made: one at or near the hamlet, Pavonia, was without reward, and the same is true of the other, about a mile north and a little east of Epworth. In the last well the Berea was reported at 600 feet, the "Big lime" at 1,500, and the Clinton at 2,475. Doubtless more money and energy will be expended in seeking oil or gas in the Clinton in Richland County, but judging from information now available the results are not promising.

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[1] Orton, Edward. *Geol. Surv. of Ohio*, Vol. VI, p. 365.

COSHOCTON COUNTY.

Records are at hand of only two wells to the Clinton sand in this county. One was drilled on the farm of William Bumpus, in Tiverton Township, near the Knox County line, in 1904. The salient features of the record are as follows:

	Thickness. Feet.	To bottom of formation. Feet.
Berea sand, base of		700
Bedford and Ohio shales	1,100	1,800
"Big lime"	950	2,750
Showing of oil at 2,330 feet.		
Break in "Big lime" at 2,650 feet.		
Clinton sand	35	2,907
Bottom of well at 2,943 feet.		

This well was shot, but made nothing better than a showing of oil.

A year later a well was drilled on the George Oxley farm near the western margin of Perry Township, and the record is similar to the one just given. The Clinton sand was reached at 2,960 feet and was 52 feet thick, but contained 4 feet of shales in the lower part. It made nothing better than a show of gas. These two wells show unusual thicknesses of sand and lead to the hope that the stratum may be both continuous and in good quantity. Prospective drillers, however, should note the increasing thickness of the "Big lime."

HOLMES COUNTY.

This county lies north of Coshocton and like that has been but little explored so far as the Clintom sand is concerned. As will be surmised, the one obstacle is the great depth. A test made on the Colopy farm in the southwestern corner of Richland Township found the Clinton sand at 3,059 feet with the following structure:

	Feet.
Sand	14
Shales	24
Sand	22

The rock was shot, but yielded nothing more than a show of oil.

On March 1, 1904, a well was begun on the farm of Peter Schlarb about three miles west of Millersburg. Troubles of various kinds, especially those resulting from heavy flows of brine, impeded the work so that the well was not completed until August 1. The record as provided by Mr. B. S. Stretton follows:

	Thickness. Feet.	To bottom of formation. Feet.
Drive pipe	86	86
Sand and shales	178	264
Casing 6⅝ inch, 264 feet.		
Shales	431	695
Berea sand	45	740
Bedford and Ohio shales	1,180	1,920
"Big lime"	1,152	3,072
Shales	21	3,093
Limestone	6	3,099
Shales	22	3,121
Clinton sand	67	3,188
Total depth 3,211 feet.		

The first salt water in the "Big lime" was found at 2,150 feet, and a much larger one at 2,806. This was cased off, but at 2,900 feet another flow was encountered and the casing was reset. The first screw in the Clinton sand the hole filled with water and the well was finished with that handicap. This report of water in the sand is most unusual and leads to the suspicion that it came from the "Big lime." The well was a total failure so far as oil and gas are concerned.

A test has also been made on the Kaylor farm along the western edge of Knox Township, the only reward being a show of gas. An unusually good record of this well was kept and is given below:

		Thickness. Feet.	To bottom of formation. Feet.
Sand and gravel		77	77
Shales and sandstone		238	315
Limestone		20	335
Shales		280	615
Berea sand		10	625
Show of oil in Berea.			
Bedford shales (red)		90	715
Ohio shales		1,010	1,725
"Big lime"	limestone 470 feet shales 7 feet limestone 443 feet brown limestone 40 feet	960	2,685
Shales		15	2,700
Limestone		35	2,735
Shales and shells		48	2,783
Black peppery limestone		9	2,792
Limestone with various colors		10	2,802
Limestone, white and soft		18	2,820
Shales and shells		31	2,851
Clinton	sand 5 feet shales and sand 9 feet sand and shales 14 feet	28	2,878
Shales and shells		6	2,884
Shales		24½	2,908½
Shales (red)		6½	2,915
Shales and shells		42	2,957

Bottom of well at 2,957 feet.

WAYNE COUNTY.

Only four wells have reached the Clinton sand in Wayne county. One of these was a total failure while the remaining three produced gas. The result, however, has fallen far short of making the search profitable. In 1909 a well was drilled on the Ryland farm in Section 6 of Plain Township, the log of which follows:

	Thickness. Feet.	To bottom of formation. Feet.
Drive pipe	40	40
Casing 8 inch, 450 feet.		
Casing 6½ inch, 2,000 feet.		
"Big lime"	1,060	2,760
Clinton sand	15	2,920
Bottom of well at 2,964 feet.		

The result was a flow of gas that was estimated at from 1,000,000 to 2,000,000 cubic feet per day and a closed or rock pressure that measured 650 pounds to the square inch. In the same year a well was drilled on a farm that joins the Ryland on the northeast. The Clinton sand was found, but was thin and without fuel of any kind. Both wells showed oil in the Berea. Early in the spring of 1910 a well was completed to the Clinton sand on the southwest quarter of Section 17 of Congress Township. The top 8 feet of the sand was of good quality, but farther down it was mixed with shales. The well is classed with the small gas producers.

The fourth test in the county was about one mile west of Wooster and was completed July 1, 1910. The well head is approximately 860 feet above sea level. For the following record and facts, the Survey is indebted to Mr. H. B. Odenkirk, of Wooster:

	Thickness. Feet.	To bottom of formation. Feet.
Drive pipe 10 inch	57	57
Berea sand	30	495
Casing 8 inch, 509 feet.		
Bedford shales (red)	50	545
Ohio shales	1,285	1,830
Heavy flow of brine at 2,055.		
"Big lime"	1,085	2,915
Salt 2,360 to 2,400 feet.		
Casing 6⅝ inch, 2,126 feet.		
Shales	189	3,104
Clinton sand	31	3,135
Bottom of well at 3,140 feet.		

After shooting the sand with 80 quarts of nitroglycerine, it began flowing gas at the rate of 1,440,000 cubic feet per day, but a week later, during which it was blowing freely into the air, it measured 325,000 cubic feet. The rock pressure was 850 pounds. It showed some oil also, but this had not been pumped when the well was visited in August, 1910. Thinking that another shot would improve the well, an effort was made to draw the tubing, but without success. The gas was used for a short time in burning bricks, and that may be its permanent service. No water was found in the sand, which lies 2,244 feet below ocean level. Interesting to note, the well disclosed 40 feet of rock salt, this being reported free from shales or other impurities. It is the farthest south that this formation has been found.

ASHLAND COUNTY.

This lies west of Wayne and has been tested to the Clinton sand at more than a dozen places. These will now be reviewed:

Vermilion Township.—This is the only township in the county that has yielded fuel in commercial quantities and that is natural gas. In January, 1910, a well was completed on the farm of George W. Long near the southern margin of Section 9. and a gas well with a closed pressure of 1,000 pounds and an open flow of 230,000 cubic feet per 24 hours secured. The well head is 1,250 feet above tide level, and the log is as follows:

	Thickness. Feet.	To bottom of formation. Feet.
Drive pipe	145	145
Berea sand	18	750
Bedford and Ohio shales	920	1,670
"Big lime"	980	2,650
Water at 1,900 feet.		
Casing 6⅝ inch, 2,015 feet.		
Clinton sand	3	2,792
Bottom of well at 2,852 feet		

Three additional wells have been drilled in the township and gas producers secured. One of these was very large and with a rock pressure of 1,075 pounds, but the yield of the remaining two was much smaller. Several locations have been made near these and the Clinton will have been reached ere these lines are in print. The thickness of the sand ranges from 3 to 20 feet.

Hanover Township.—About 1905 a well was drilled on the Stull farm near the southern margin of the township. The Clinton sand, two feet thick, was found at 2,763 feet, but was without oil or gas.

Green Township.—A well to the Clinton sand is reported about one mile north of Perrysville, but no information has been secured concerning it beyond the fact that it was dry.

Mohican Township.—A Clinton well is reported a short distance northwest of Jeromeville, but it disclosed neither oil or gas.

Jackson Township.—March 9, 1906, a well was completed on the Utz farm, northwest quarter of Section 21, the altitude of the well head being 1,265 feet. The following record of this well was secured:

	Thickness. Feet.	To bottom of formation. Feet.
Berea sand	15	670
Bedford and Ohio shales	995	1,665
"Big lime"	1,100	2,765
Shales	96	2,861
Clinton sand	12	2,873

The sand lies 1,611 below sea level while in the Long well it was only 1,539, a drop of 72 feet in 12 miles or 6 feet to the mile, the direction being nearly northeast.

The Utz well showed oil, was shot and the pump attached. The yield, however, was small and the well was soon abandoned. Encouraged by this, another hole was drilled in 1909 just across the road, a good flow of gas being secured, but this soon gave out. Two additional wells have been drilled in this township; one in the northeastern corner on the Landis farm in Section 3, and one in the southwestern corner on the Kelley farm in Section 29. The first found 3 feet of sand, the second little or none, and both wells were failures.

Ruggles Township.—Three wells have been reported in this township, but the data are very indefinite and unsatisfactory. Possibly two may not have reached the Clinton. All were failures.

MEDINA COUNTY.

Quite a number of Clinton wells have been sunk in the southwestern corner of this county, the result being 4 gas wells, one oil well and 3 dry holes. From two to three miles south of west of Lodi is the most promising territory. Even there the sand is thin, ranging from 5 to 12 feet, and the wells rather small. The general rock succession is shown by the following record of E. S. Albert well No. 1, the head being 920 feet above sea level:

	Thickness. Feet.	To bottom of formation. Feet.
Berea sand	10	396
Bedford and Ohio shales	1,116	1,512
"Big lime"	1,127	2,639
Water at 1,722 feet.		
Clinton sand	14	2,763
Bottom of well at 2,777 feet.		

This well is northeast of those in Jackson and Vermilion Townships of Ashland County, whose sea level position has already been stated. The sand in the Albert well record, just given, lies 1,829 feet below sea level, a drop from the Utz well (page 62) of 218 feet or 27 feet to the mile.

North of the Lodi field a number of tests have been made. One in Chatham Township found the sand dry, while farther north, in Litchfield, the result is somewhat mixed. Near the middle of the southern part a dry hole was secured; but about two miles farther north, on the Stranahan farm, an oil well, starting at about 10 barrels per day, was the reward. In this the Clinton sand lies about 1,739 feet below sea level. Encouraged by this result, another test is being made about a mile to the west. Near the southern margin of Penfield Township a gas well has been secured and two additional tests are now being made, one north and one west of the producer.

LORAIN COUNTY.

This county, which borders on Lake Erie, has been tested at a number of places, and in Avon Township nearly 30 wells have been drilled, of which 15 were total failures. Following is a record of Kenzel No. 1, in the southeastern quarter of the township:

	Thickness. Feet.	To bottom of formation. Feet.
Drive pipe	63	63
Bedford and Ohio shales	957	1,020
"Big lime"	1,325	2,345
Casing $6\frac{5}{8}$ inch, 1,425 feet.		
Salt from 1,535 to 1,570 and from 1,680 to 1,698.		
Clinton sand	8	2,420
Bottom of well at 2,480 feet.		

The Ohio shales lie immediately below the drift in this territory, and so the Berea does not appear in the well record. The "Big lime" contained much water, filling the hole 2,000 feet, but the Clinton sand, 1,722 feet below sea level, was free from water as well as oil and gas. Salt was found at two horizons in the "Big lime," and this useful mineral is reported in every well as far west as the meridian passing through Elyria. The Clinton sand usually ranges from 4 to 15 feet in thickness, but sometimes is wanting. The rock pressure for the field is about 1,000 pounds to the square inch, and the largest well is reported as having started flowing at the rate of 5,000,000 cubic feet per day. In general the wells are much smaller, and this fact, with the very large proportion of dry holes, has made the territory unprofitable.

Ridgeville Township lies south of Avon and has been tested at three places, one each in the northeast and northwest corner, and one between these and a little farther south, but all were failures. In Sheffield Township, west of Avon, one test has been made, the location being near the Lorain & Elyria Electric R. R., and about a half mile from the southern line of the township. The head was about 650 feet above sea level, and the log is as follows:

	Thickness. Feet.	To bottom of formation. Feet.
Drift and shales	840	840
"Big lime"	1,230	2,070
Water at 1,075 feet.		
Clinton sand	7	2,204
Bottom of well at 2,405 feet.		

This well is reported as showing 80 feet of rock salt, but neither oil nor gas. The top of the sand lies 1,547 feet below ocean level, a rise of 64 feet from the Utz well, which is 32 miles nearly due south. In other words, the southward dip of the sand in this part of Ohio is less than 2 feet to the mile. Some years ago a well was drilled at Oberlin, but no record has been secured of it. Neither oil nor gas was found.

It may be worth while at this place to give a record showing the Trenton limestone, since many prospectors are not clear as to the position of the "Big lime" and Clinton with reference to the Trenton. The record which follows is that of the Citizens Well No. 1, drilled at Norwalk, in 1887:

	Thickness. Feet.	To bottom of formation. Feet.
Drift	85	85
Bedford and Ohio shales	355	440
"Big lime"	850	1,290
Niagara and Clinton shales and limestones	400	1,690
Medina shales	110	1,800
Ordovician (Lower Silurian) shales and limestones	845	2,645
Trenton limestone at 2,645 feet.		

This log does not show the Clinton sand for the simple reason that it does not extend that far west, its place being occupied by shales.

CUYAHOGA COUNTY.

Many tests for oil or gas have been made in this county. In 1886 a well was drilled at Newburg, in search of gas for a rolling mill, but at a depth of 3,000 feet the tools became fast in the well and it was abandoned. According to Orton, work was suspended in the Clinton limestone which forms the basal part of the "Big lime."[1] A little gas was secured, and another well soon started, but with no better success. Since that time a number of tests on the western side of the county have reached the Clinton sand, but with little or no success. A well on the White farm just west of Rocky River showed a little oil, and that is occasionally dipped from the well by farmers and used as a lubricant.[2] Possibly the source of this was in the "Big lime" rather than in the Clinton sand.

In the summer of 1907, the East Ohio Gas Company drilled a well on the Gray farm about one mile north of Berea. The "Big lime" was struck at 1,075 feet and at 1,280 a flow of gas, reported at 500,000 cubic feet, was found. Work continued to 3,200 feet without finding the Clinton sand, and the well was abandoned.

About the same year (1907), three wells were drilled near Olmsted Falls, two of which were total failures, while the third yielded a little gas, though no use has been made of it. This well is on the Garfield and Caine farm and is about one-half mile west of the village. The record as furnished by the East Ohio Gas Company follows:

	Thickness. Feet.	To bottom of formation. Feet.
Drift	10	10
Drive pipe 10 inch, 19 feet.		
Berea sand	80	90
Casing 8¼ inch, 85 feet.		
Bedford and Ohio shales	1,120	1,210
"Big lime"	1,455	2,665
Casing 6⅝ inch, 1,540 feet.		
First salt water at 1,480 feet.		
Casing $5\frac{3}{16}$ inch, 2,613 feet.		
Heavy flow of water at 2,450 feet.		
Showing of oil at 2,300, 2,355 and 2,390 feet.		
Clinton sand at 2,680 feet.		
Total depth of well 2,770 feet.		

The well head is 780 feet above ocean level, and hence the top of the Clinton sand lies 1,900 feet below the same datum plane.

For the convenience of persons desiring to know the position of the Clinton sand in Northern Ohio, the following summary is given·

Ashland County.
    Vermilion Township.
        Long well No. 1 .... 1,539 feet below tide level.
    Jackson Township.
        Utz well No. 1 .... 1,611 feet below tide level.

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[1] Orton, Edward. *Geol. Surv. of Ohio*, Vol. VI, p. 352.

[2] Manuscript of Professor Frank Carney.

Wayne County.
Wooster......................2,244 feet below tide level.
Medina County.
Harrisville Township.
E. S. Albert well No. 1 ....1,829 feet below tide level.
Lorain County.
Avon Township.
Kenzel well No. 1..........1,722 feet below tide level.
Ridgeville Township.
Sheffield well No. 1 ....1,547 feet below tide level.
Cuyahoga County.
Olmsted Township.
Garfield and Caine well.....1,900 feet below tide level.

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